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The SCIENTIFIC MONTHLY

June 1944

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THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Founding and Organization

In 1848, on September 20, the Association was formally organized and held its first meeting; in 1874 it was incorporated under the laws of the Commonwealth of Massachusetts and given the right to receive, purchase, hold and convey property. Its governing body is a Council, now having 255 members.

The Association is national in scope, with membership open to the whole world on equal terms, and its interests include the broad fields of the natural and the social sciences. Its varied activities are carried on under 16 sections with which 189 affiliated and associated societies, having a combined membership of nearly a million, cooperate in organizing programs for its meetings.

Members and Meetings

All persons engaged in scientific work, all who find pleasure in following scientific discoveries, all who believe that through the natural and social sciences a better society may be achieved are eligible for membership in the Association. From its founding, the most distinguished of American scientists, including every American Nobel Laureate in science and every president of the National Academy of Sciences, have been members. The names of many university presidents, of eminent scholars in widely different fields, and of men notable for public service, including a United States Senator, a Justice of the Supreme Court, and a former president of the United States, are now on its roll of more than 25,000 members.

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Opportunity and Responsibility

A world torn by conflicts and fearful of the future is looking more and more toward scientists for leadership. The opportunity for unparalleled service is theirs and the fact that they have available the only essentially new methods, if not purposes, imposes an equal responsibility. For these reasons it will be the Association's steadfast purpose to promote closer relations among the natural and the social scientists, and between all scientists and other persons with similar aspirations, to the end that they together may discover means of attaining an orderliness in human relations comparable to that which they find in the natural world about them.

MEET THE AUTHORS

ALBERT L. ELDER, Ph.D., recently became Director of Research of the Corn Products Refining Company, Argo, Illinois; but for present purposes greater emphasis should be placed on his preceding position as Head Chemical Advisor of the War Production Board and Coordinator of the Penicillin Program, the development of which he describes in his present article. Dr. Elder was born in Lexington, Illinois, in 1901 and took all his degrees at the University of Illinois. From 1928 to 1930 he served as instructor of chemistry at Oberlin College. Syracuse University claimed his talents until 1941 when he moved to the War Production Board in Washington, D. C. Before taking charge of the penicillin program he was the WPB representative for the Patent Office War Division and was closely associated with the early development of synthetic rubber and with labor problems in chemical industry. He did not leave WPB until the production of penicillin was well established.

EDWARD J. STIEGLITZ, M.S., M.D., F.A.C.P., is engaged in private practice of internal medicine at 1726 Eye St., N. W., Washington 6, D. C. The son of the famous chemist Julius Stieglitz, he was born in Chicago in 1899. His premedical education was obtained at the University of Chicago and his M.D. at Rush Medical College where he taught histology and, later, internal medicine until 1938. During the next two years he served as medical adviser in the U. S. Department of Labor and in 1940 initiated the formation of a Unit in Gerontology at the National Institute of Health, a research activity now suspended by pressure of war. Dr. Stieglitz, a brilliant and sagacious physician, is primarily interested in the chronic, progressive disorders of later maturity. In a recent and most successful text on Geriatric Medicine, which he edited, he wrote: "The longer men live the more time there is to think. To think is to grow, and, growing, live."

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A well-known lawyer and agriculturalist views the future and advocates caution in international commitments. He discusses questions of national and international relations, of freedom and self-help, of rising populations and of the need for food and for agricultural education. Constructive proposals are offered.

Mankind So Far. WILLIAM HOWELLS. xii + 319 pp., illus. 1944. $4.50. Doubleday, Doran, New York.

This book is the fifth volume of The American Museum of Natural History Science Series. Part I deals with "Animals and the Coming of Man," Part II with "Man and the Coming of Homo Sapiens," and Part III with "Homo Sapiens and the Coming of Races," ending with speculations on the future of the human race.

Personality and the Behavior Disorders. Edited by J. McV. HUNT. 2 vol. xii + 618 and v + 619–1241 pp., illus. 1944. $10.00. The Ronald Press, New York.

Thirty-five chapters by forty specialists cover the major portion of theory, investigative fact, and clinical practice representing present knowledge of the behavior of whole individuals. Although technical jargon is minimized, this documented book is intended for advanced study and not for casual reading.

The Illustrated Encyclopedia of American Birds. LEON AUGUSTUS HAUSMAN. xix + 541 pp. 1944. $1.98. Halcyon House, New York.

Anyone who has an urge to identify the birds of his neighborhood and learn something about their habits will find the answers to his questions in this inexpensive but comprehensive book, which was written by a man who enjoys "birding" like an amateur and knows birds like a professional ornithologist.

Middle America. CHARLES MORROW WILSON. 317 pp., illus. 1944. $3.50. W. W. Norton & Co., New York.

Middle America is the name coming into use for Central America and the adjacent island republics. Here is the story of their peoples, products, and problems and of their importance to the United States. The agricultural wealth of Middle America is stressed and new products are described.

Radio Research 1942–1943. Edited by PAUL F. LAZARSFELD and FRANK STANTON. xvi + 599 pp., illus. 1944. $5.00. Duell, Sloan & Pearce, New York.

The title of this book may be misleading, for it has nothing to do with the physics of radio but is concerned with psychology as indicated by the title of the first chapter, "What Do We Really Know about Daytime Serial Listeners?" The book might have been entitled "Radio and Its Public."

Rockets. WILLY LEY. xi + 287 pp., illus. 1944. $3.50. The Viking Press, New York.

A serious case is made for the possibility of future travel beyond the stratosphere. The author develops his story historically, describes recent experiments on rocket propulsion, and, finally, considers the practicability of the "spaceship" and its operation. This book should have great popular appeal.

* Orders for the books noticed above should not be sent to THE SCIENTIFIC MONTHLY or the A.A.A.S., but to your bookseller or the publisher.

MEET THE AUTHORS, Continued

HOWARD B. ADELMANN, Ph.D., Professor of Histology and Embryology at Cornell University, was born in Buffalo, N. Y., in 1898. All his predoctorate education was obtained at Cornell; his postdoctorate at Freiburg, Germany, with Hans Spemann, and at Columbia with S. R. Detwiler, in experimental embryology. Except for his years as a Fellow of the National Research Council and for two years as Assistant Professor of Anatomy at Columbia, Dr. Adelmann has taught histology and embryology at Cornell since 1919. But his mind has ranged far above and beyond Cayuga's waters, back through the history of embryology and forward into the mysteries of the development of animals. His monograph *The Embryological Treatises of Hieronymus Fabricius of Aquapendente* won him the Crofts prize for the most distinguished manuscript published by the Cornell University Press during 1943.

L. H. WOODMAN, A.B., is Associate Editor of the *Dow Diamond*, house organ of The Dow Chemical Company at Midland, Michigan. Graduating from Michigan State College in 1934, Mr. Woodman fought the depression until he became a newspaper man. He entered Dow's legal department in April 1943 and transferred to the Company's writing staff in September. Dow is one of the country's great chemical industries. The visitor to the Company's headquarters will enter the attractive doorway shown below and will learn that the Company not only produces plastics but magnesium, bromine, phenols, and dozens of other chemicals used in our war industries. Acknowledgment is made to Dow for the following photograph of the Company's main office building and for all illustrations of Mr. Woodman's article.

MEET THE AUTHORS, Continued

MARY ELLEN GOODMAN is a Fellow in Anthropology at Radcliffe (see p. iv, preceding issue).

ADMIRAL L. O. COLBERT is Director of the United States Coast and Geodetic Survey (see p. 443, this issue).

GUSTAF ADOLPH PEARSON, M.A., Senior Silviculturist of the U. S. Forest Service, may be addressed at Box 951, Tucson, Arizona. He was born in Nebraska in 1880 and educated at the State University where he was inspired by the late Dr. Charles E. Bessey. Entering the Forest Service in 1907, he began his lifework in 1908 when he organized the Fort Valley Forest Experiment Station, first of its kind in the United States. Here near Flagstaff, Arizona, he has since directed the harvesting and restocking of the native pine forests, placing them under intensive management. For thirty years some forty thousand individual trees have been measured, yielding a unique and valuable long-time record. An ardent believer in forestry as an essential national enterprise, Mr. Pearson has literally lived his life among the trees.

EDWARD TAUBE, Ph.D., F.A.G.S., is Assistant Professor of German at the University of Western Ontario, London, Canada. He was born in eastern Poland, grew up in western Canada, graduated from the University of Alberta, and worked for his doctorate at Wisconsin, Cologne, and Berlin. Later he carried on research at Harvard and the University of California. Dr. Taube has given considerable time to research on German crafts and language in their relationship to England and the English language. Aside from trying out new numbers on the violin or engaging in a lively game of tennis, he enjoys above all else puzzling over words listed in the dictionaries as of unknown origin, thinking out their derivations, and searching for related philological, historical, or scientific details.

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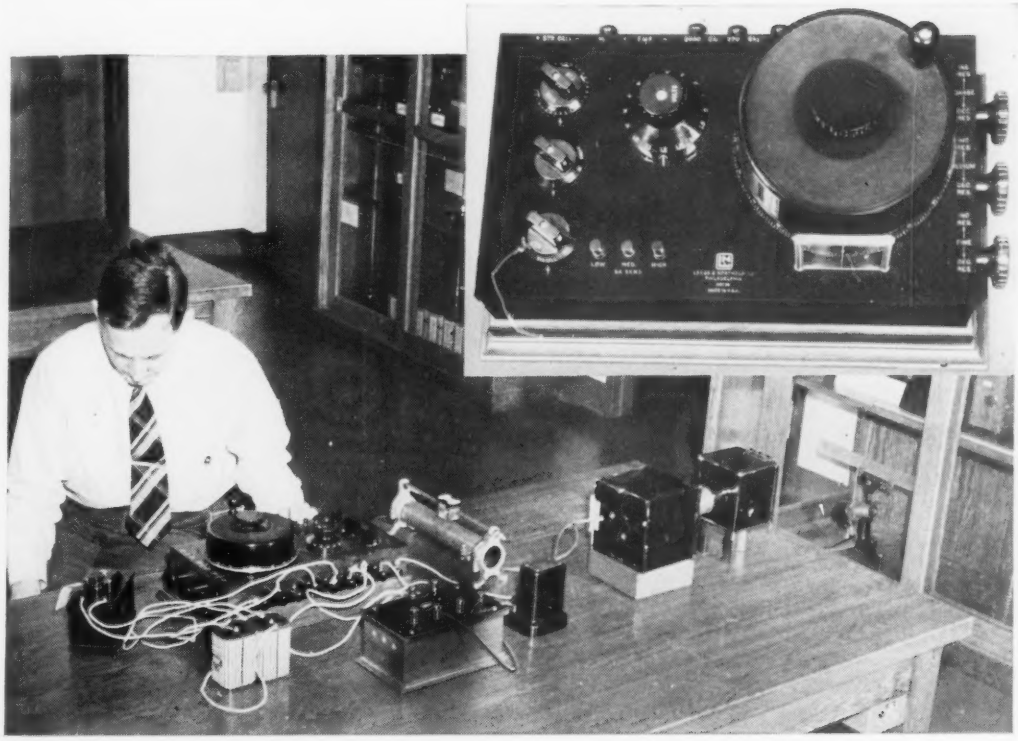
MEET THE AUTHORS, Continued

CHARLES GLEN KING, Ph.D., has been Scientific Director of the Nutrition Foundation, Inc., since it was organized by the food industry in 1942. His office is in the Chrysler Building, New York City, far removed in every sense from Entiat, Washington, where he was born in 1896 and where he grew up on a fruit and stock farm along a trout stream. He graduated from Washington State College in 1918 and enlisted in a Machine Gun Company of the 12th Infantry. Following the Armistice he took his doctorate in biological chemistry at the University of Pittsburgh and after a year of postdoctorate study at Columbia he returned to Pittsburgh to teach chemistry and conduct research on synthetic fats, vitamin C, enzymes, tissue respiration, and nutrition. His work has been recognized not only by his appointment to his present influential position, but by three special awards and by several important assignments in the American Chemical Society.

CHARLES JUDSON HERRICK, Ph.D., Sc.D., is Professor Emeritus of Neurology, University of Chicago—a distinguished member of a remarkable faculty. He now resides at 236 Morningside Drive, Grand Rapids 6, Michigan. He was born at Minneapolis in 1868 of pioneer parents, whose pioneering spirit was transmitted to him and his brothers, in whom it took the form of scientific exploration. Each of the schools at which he studied (Cincinnati, Denison, and Columbia) later honored him for his work in comparative neurology by bestowing upon him the degree of Doctor of Science. In addition to his teaching and research at Denison (1898–1907) and at The University of Chicago until his retirement in 1934, he has established an amazing record as Editor of the *Journal of Comparative Neurology*. During fifty years he saw seventy-seven volumes of this Journal through the press and he still participates in editorial work on it. Dr. Herrick finds that life at seventy-five years is good.



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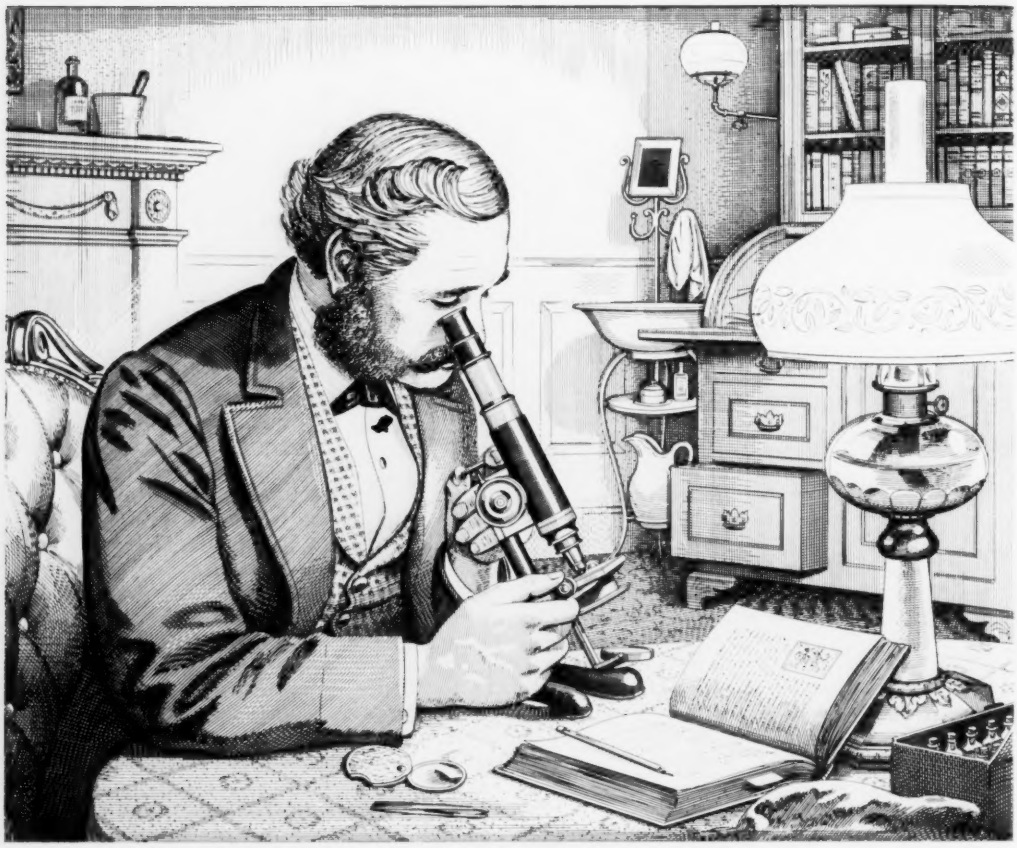

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PENICILLIN*

By ALBERT L. ELDER

For centuries man has depended, directly or indirectly, upon fermentation reactions for the destruction of waste materials and the production of valuable compounds. As an example, the beverage industry, which dates back to Biblical times, has been developed to a very high technological state, and further improvements in yield or decrease in the time cycle may be difficult to attain. Present day competition between some synthetic and fermentation processes is keen, and there is reason to expect that it will continue to be so. Many commercial fermentation processes result in high conversions of carbohydrate into the desired end product. Among the high yield fermentations are those of alcohol, acetone, acetic acid, butanol, butyric acid, citric acid, glycerol, gluconic acid, kojic acid, lactic acid, and l-sorbose, for in these the conversion of carbon into the desired material varies from 20 to 97 percent. It is only within recent years that attempts have been made to harness low-yield fermentation reactions on a commercial scale and to isolate desired substances therefrom.

Based on the cost of equipment for its production, penicillin is by far the most important of the low-yield products. At the present time, the formulas for fermentation media used in producing penicillin vary greatly in different plants, but calculated on carbon content of media converted into carbon in penicillin, the yield is only about 0.005–0.1 percent. Yields of this order of magnitude are most fascinating to the scientist, for he dreams of the day when he might obtain one percent conversion. It is almost incredible that we would spend approximately twenty million dollars on equipment in which to carry out such an inefficient reaction. But we who have been connected with the commercial production of penicillin are proud of the accomplishments thus far, yet humble when we realize how little is known about the mold, *Penicillium notatum*, and the mechanism by which it produces penicillin.

Several crystalline antibiotic substances have been obtained from bacteria and molds. These substances have the capacity of inhibiting growth and destroying various bacteria. In general, they are bacteriostatic, rather than bactericidal, and are selective in action. In vivo their bacteriostatic ability may differ greatly from that in vitro. At the present time, penicillin is the most important of these antibiotic substances, for it is reasonably nontoxic and therefore can be used in vivo. It is particularly effective against most of the gram-positive cocci and bacilli, and the gram-negative diplococci. Streptococci, staphylococci, pneumococci, the clostridium group, gonococci, meningococci, and spirochete and actinomycete infections respond to its use. Penicillin has not been shown to be effective against the gram-negative bacteria, tubercle bacillus, malarial parasite, Friedländer's bacillus, and many others. Although called the "miracle drug," its uses *are limited* and the method of handling the drug clinically leaves much to be desired.

At present penicillin is delivered to the physician as penicillin sodium, the sodium salt of an organic acid. Several other metal-

* An address delivered on March 29, 1944, at the Tenth Annual Chemurgic Conference, St. Louis, Mo. Acknowledgement is made to the National Farm Chemurgic Council for permission to publish it.

lic salts have been prepared, and it is quite likely that some other one may soon supersede the sodium salt. Penicillin is affected unfavorably by high temperatures, moisture, and acidic and basic conditions. At present the ampoules of the drug are kept at temperatures below 10° C. (50° F.) and have an expiration date of three months from date of testing and filling, except for three companies with a six months' dating and one with four months. Because great losses are encountered in purifying the drug, it is used in the relatively impure state, but before long a product containing at least 50 percent penicillin should be produced on a commercial scale. The pure salt is crystal clear. At present penicillin is administered intramuscularly, intravenously, by lumbar puncture, directly into joint and cavity spaces, and locally—oral administration is not effective. The amount required per case ranges from about 100,000 units to a few million. One billion units of pure penicillin weighs approximately one pound. It is hoped that someone will discover a derivative of penicillin which can be administered orally and further that the stability of the drug will be improved greatly. Also, it is possible that some derivative of penicillin might have a much wider bacteriostatic action.

Numerous articles have been written pertaining to the accidental discovery of the bacteriostatic action of *Penicillium notatum*. It is with considerable chagrin that we must admit that a drug of such potential usefulness remained dormant for so many years. Were it not for the war, it is most likely that it would still be little more than a laboratory curiosity. The bacteriostatic effect of penicillin was first observed by Dr. Alexander Fleming, Professor of Bacteriology at St. Mary's Hospital, London, in 1929. A spore of the mold contaminated a Petri dish containing a culture of *Staphylococcus aureus*. The growth of this organism was inhibited by the mold, later identified as *Penicillium notatum*. Fleming studied the material and suggested that it might have clinical value, *if* it could be produced on a larger scale.

Professor Harold Raistrick of the London School of Hygiene and Tropical Medicine produced larger quantities of penicillin and studied its properties in some detail. He urged that it be subjected to clinical tests, but the small yields made this impractical at the time of his publication in 1932. For seven years little was done with penicillin. In 1939 the Oxford group under the leadership of Dr. H. W. Florey revived penicillin as a possible war-time drug. In 1939 a Rockefeller grant of $5,000 was made to support the work and again in 1941 another $5,000 grant was made. In July, 1941, Dr. Florey and his associate, Dr. N. C. Heatley, visited the United States and made their findings available to some American workers. The early work in the United States was under the guidance of the Office of Scientific Research and Development.

During the past two and one-half years penicillin has gone through all the growing pains usual to any new industry. Production was still in the laboratory stage when information about it was brought to the United States in 1941. The yields were hopelessly low, and the recovery process was far from satisfactory. War-time conditions in England made its rapid development very difficult in that country. Among those contacted in the United States was Dr. Robert D. Coghill, Fermentation Division, Northern Regional Research Laboratory. His group, with their broad experience in fermentation, tackled the problems of increasing the yield and recovery. Dr. A. J. Moyer, a co-worker of Dr. Coghill, discovered that the addition of corn steeping liquor to the medium upon which the mold grew increased the yield tenfold. New strains were developed, and in a short time the yield had increased from two up to forty Oxford units per cubic centimeter.

Within a few months the firms of Merck, Squibb, Pfizer, Abbott, and Winthrop were producing enough penicillin for some clinical tests. As clinical results were obtained, the potential usefulness of penicillin became more exciting. Only experimental quantities of penicillin were produced in 1942, and only 400 million units during January to June of 1943.

The armed forces recognized that thousands of lives might be saved if penicillin could be produced on a commercial scale. The responsibility for this production rested

with the Drugs and Cosmetics Section (now a Branch) of the Chemicals Division of the War Production Board. Mr. Fred J. Stock, chief of this Section, was given "guestimates" for requirements and promises for processes, and on this footing the program was launched. Mr. Stock recognized the potential usefulness of the drug and therefore urged industry to tackle this problem.

During the next few months processes were improved. Starting from the drawing board, plants had to be built. Most of the construction program was done during the months of October, 1943 to March, 1944. The production in June was 0.4 billion units; July, 0.7; August, 0.8; September, 1.7; October, 2.8; November, 4.8; and December, 9.1. The production in March should be at least twice the total production in 1943 and rapid increases should follow each month for several months to come.

The production of penicillin may be divided into the following steps: (1) isolation of a pure culture of *Penicillium notatum* and recovery of spores of the mold, (2) preparation of inoculum from pure spores, (3) preparation of a sterile medium, (4) inoculation of suitable medium with spores under sterile conditions, (5) growing cycle under careful control of air and temperature, (6) separation of mycelium from liquid medium containing the penicillin, (7) concentration and recovery of penicillin, (8) packaging under sterile conditions, and (9) assay of products.

Many methods have been suggested for growing penicillin, and the War Production Board evaluated carefully all proposed processes. Great publicity was given to the cookstove method, the utilization of the home photographic darkroom, and several others. The man-hours required to produce appreciable amounts of penicillin and the lack of uniformity of product made such proposals untenable. Four methods have been tested in great detail. These are known as the trickle process, the bran process, the surface process, and the submerged process.

In the trickle process the inoculated broth is allowed to flow over stones or wood chips under aerobic, sterile conditions. The liquid flows by the mold, which clings to the supports. It is an adaptation of the "quick" vinegar process. Based on its present yields, the cost of equipment is such that this process is not promising.

Sterile bran can be inoculated with spores and penicillin extracted from the bran after a suitable incubation period, but size of equipment and difficulties with temperature control and sterilization have been troublesome. The cost of operation of such a plant cannot be evaluated at the present time.

The oldest method for producing penicillin was that of growing the mold on the surface of a quiescent medium under sterile conditions. Flasks, milk bottles, and trays are used. Some of the "bottle" plants must handle many thousands of bottles per day. Yields are good, growing cycles are long, and labor costs are high. Unless some improvements are made in the process, bottle plants cannot operate as economically as the deep fermentation plants.

Penicillium notatum has the interesting characteristic of growing also under submerged conditions. Different strains are used for the submerged process. The mold, as it grows in the broth, is aerated for several days in large fermentors. At the end of the fermentation cycle the mycelium is filtered and discarded, and the penicillin is recovered from the broth. Tanks holding several thousand gallons are now in successful operation, and should the expected improvements follow, this procedure assures us of a high output and cheap method for the production of penicillin.

The recovery of penicillin from the broth follows somewhat the same pattern irrespective of culture media or growing conditions. At the end of the growth cycle penicillin is present as a soluble salt in the broth in a concentration in the range of that of bromine in sea water; but recovery of bromine from sea water is simple when compared with the recovery of penicillin. Many of the chemists' tools and tricks of the trade have been applied to the problem. Several methods have been developed and although some are usable, none is entirely satisfactory. The procedure first published by the Oxford group depended upon acidifying the broth to a pH of 2.0 to 3.0, extracting the penicillin with a small volume of an organic solvent

such as chloroform or amyl acetate, and then extracting the penicillin from the organic solvent with an alkaline solution. By appropriate cycling, purification and concentration can be accomplished. Approximately 50 percent of the penicillin is lost during the recovery process. If this serious loss can be reduced, production may be increased without further plant expansion.

Penicillin is unstable in aqueous solutions and therefore must be packaged as the dry salt. The technique used to dry blood plasma has been applied to the drying of penicillin. Although this method is workable, costly equipment was necessary, because time was lacking to develop a cheaper method of drying.

Since the final substance must be injected into the body, elaborate procedures are used to insure a nontoxic, sterile, pyrogen-free product of uniform potency. This phase of the program is under control of the Food and Drug Administration. The labor required for such controls makes it impractical for hundreds of producers to enter the field.

As coordinator of the penicillin program from October, 1943, to March, 1944, it was my privilege to participate in this thrilling development. It has been a three-way race all through this program among rushing to completion the eighteen plants in the United States and two in Canada, developing a suitable process so the plants could operate when they were physically completed, and trying to synthesize penicillin. Some companies were pushing one group of men to get a plant built, another group to develop a suitable fermentation process for the plant, and still another group to learn how to synthesize penicillin. If the last had been successful, the fermentation plant might have become obsolete before completion.

The army expediters, under the able supervision of Major Frank Sleeter, assisted the War Production Board staff in breaking bottlenecks in equipment and construction materials. The speed with which some of the plants were built is testimony to American initiative.

The Office of Production Research and Development of the War Production Board was called in to break technical bottlenecks, and research projects were started almost overnight at Pennsylvania State College, University of Wisconsin, University of Minnesota, Massachusetts Institute of Technology, and Stanford University. Dr. T. K. Sherwood at M. I. T. advised on methods of drying and packaging the final product. Fermentation problems were assigned to Dr. W. H. Peterson and his group at the University of Wisconsin. Dean Whitmore of Pennsylvania State College placed a group of chemists and chemical engineers on recovery processes. Plant pathologists, led by Dr. E. C. Stakman at the University of Minnesota, have been organized to search for new and better strains of molds which produce penicillin. The group at Stanford, under Dr. G. W. Beadle, have been assigned the problem of producing changes in the mold which may increase the yield of penicillin. The army assigned Capt. A. B. Hatch to my office to follow the biological developments. Samples of soil have been collected from all parts of the world, and a systematic program has been outlined in an attempt to improve the yield.

Additional research on penicillin, some of which was sponsored by industrial firms, has been carried on for some time at Northwestern University, Columbia University, The Ohio State University, and several others.

A very low order of probability exists that we are now using the best possible strain of *Penicillium notatum*. To pick the winner would be like choosing the winning horse in a race with a thousand horses at the gates. Measuring the productivity of a mold is slow, tedious work, and attempts to produce changes in the mold may be unfruitful. However, work of this kind, if successful, could increase production so greatly, that anyone connected with the program who failed to consider and investigate these possibilities would be failing to meet his responsibilities. Since October 1, 1943, Dr. L. A. Monroe has been devoting full time to coordinating the O.P.R.D. projects, and his assistance has been of great value in developing the technical aspects of the program.

In October, 1943, the governmental responsibilities in connection with penicillin were established on clear-cut lines. The re-

sponsibility for the production of penicillin by fermentation methods was taken over by the War Production Board, and the synthesis of penicillin was left under the control of Dr. A. N. Richards and his Committee on Medical Research of the Office of Scientific Research and Development. The recovery of pure crystalline penicillin from mold has been reported in the newspapers. Progress on synthesis is clothed in deep veils of secrecy, but we shall know eventually whether the program was a dismal failure or a brilliant success. Should synthesis not be announced in the near future, new groups of chemists will undoubtedly tackle the problem.

At a dollar per 100,000 units, penicillin would cost about $10,000 per pound. Therefore, attempts to synthesize penicillin will continue for some time to come. The question is frequently asked, "What will happen to the twenty million dollar fermentation investment if penicillin can be synthesized economically?" The plants producing penicillin by submerged methods can be converted quickly to produce other chemicals by fermentation methods. The bran plants are also applicable to other uses. The bottle plants may be saved by the development of other antibiotic substances. If not, some of the equipment will be of little use. In fact, the bottle plants, although the surest bet a year ago, may be forced out of production within the next year, even though penicillin is not synthesized.

The distribution of penicillin for civilian use up to the present time has been under the control of Dr. Chester S. Keefer, Evans Memorial Hospital, Boston, Massachusetts. His job has been most trying, and one exceptionally well done. The clinical research under his supervision has been carried forward very rapidly. As soon as the needs of the armed forces can be met, penicillin should be available for civilian use. Difficulty is to be anticipated in the equitable distribution of so valuable a drug when the demand exceeds the supply. The potential demand for penicillin cannot be evaluated with any degree of accuracy until more is available for clinical tests on humans and animals. The needs of the world for the drug are staggering. Its value in treatment of animal diseases has not been tested. The final price of penicillin will determine its use for many purposes.

Approximately fifty different chemicals are required for the preparation of inoculum and culture media, and for the recovery and testing of penicillin. Mice and rabbits are needed for animal testing. The raw material requirements for the preparation of a suitable substrate and for the recovery processes run into millions of pounds per year. Fortunately, there is at least one substitute material for nearly every step in the process. Thus although one sugar may be excellent for the fermentation media, by proper modification other carbohydrates may be used. Even though corn steeping liquor has been shown to be a valuable adjunct to the media, it is quite likely that still better substances will become available. Several organic solvents can be used in the recovery process. The salvation for large-scale production of penicillin has been the recognition that several methods for its recovery had to be developed. If a single process had been selected and only one recovery system used, the construction of the plants could not have been attained in such a short time; and even though physically completed, the raw materials would not have been available for the operation of the plants. To have standardized the process five months ago would have stifled progress. Attaining maximum production today depends upon the efficient harnessing of the "know-how" recently developed by the technical men.

The one American deserving of the most credit for his contribution in the penicillin program is Dr. Robert D. Coghill, Chief of the Fermentation Division of the Northern Regional Research Laboratory. His group made commercial production a reality, and his fundamental research, which is still being continued, adds each day to the knowledge required to hasten civilian distribution of penicillin. Also, hundreds of technical men throughout the industry have worked as never before to push this program to the limit. The close cooperation between government and industry has resulted in one of the most rapidly developed programs since the war began.

SENESCENCE AND INDUSTRIAL EFFICIENCY*

I. THE GENERAL PROBLEM

By EDWARD J. STIEGLITZ

THE primary object of industrial health activities is to increase work efficiency of personnel and thereby to reduce costs and speed production. Both historically and in present day application industrial health is divisible into three distinct fields of effort. The earliest phase was limited to surgical and medical repair and rehabilitation of employees injured on duty. Later came recognition that physical injuries could be prevented by control and improvement of the work environment. Thus industrial hygiene was born. Its growth has been rapid and dramatic. The Industrial Hygiene Foundation of America was created to foster further improvement of the work environment; its accomplishments are too well known to require comment. The third, and as yet only scantily developed phase of industrial health, consists of efforts directed toward improvement of the health of individual workers so that they may be more effective in any environment.

Man's ability to work is affected by many factors. These fall into two large categories. First are those factors arising from adverse environmental conditions. Extreme heat or cold, improper illumination, annoying and irritating dusts or fumes definitely impair work efficiency, even without taking into consideration their cumulative ill effect upon health. These are the exogenous factors. Though of vital importance to industrial health maintenance, they are outside the field of this discussion. The second category of factors affecting work efficiency are endogenous; they arise within the worker himself. To maintain maximum efficiency, the human machine must be mentally and physically healthy. Ill health occurs in many degrees; impairment of work capacity is equally variable. Acute illness may make for temporary total incapacity. Chronic illness may either cause brief periods of recurrent total incapacity or continuing partial impairment. Physical defects may limit capacity to work to certain tasks. Fatigue and other intoxications reduce industrial efficiency. Age likewise affects work capacity.

Senescence is that part of aging which occurs after the peak of full maturity. Aging is a series of changes which begin with conception and end only with death. Though continuous, the rate of change is not uniform. The first overt consequences of senescence usually become manifest somewhere near forty years of age, although occult changes have been progressing for years before this time. For convenience in discussion we may divide the later half of life into three periods: later maturity or early senescence (approximately 40 to 60 years), late senescence (60 to 75), and senility (after 75). The critical period is that of later maturity or senescence.

NEED FOR KNOWLEDGE

Interest in the science of gerontology, which is the study of aging, is relatively recent. Aging was long taken for granted. The false notions that senescence is all decline, that it is merely the precursor of senility and death, and that nothing can be done about it are still held far too commonly. True, the aged, like taxes, have always been with us, but never in such alarming numbers as today. It is the recent tremendous relative and absolute increase in the number of elderly persons which makes urgent the need to learn much, much more about senescence than we now know and to apply with energy and intelligence that which we already have learned. The radical changes in population structure are of great significance to every man, woman, and child in this great country, but most particularly they are of moment to Industry.

In 1900, the average life expectancy at birth in the United States was only 47 years; in 1930 it had risen to 60 years and in 1940 to over 63 years. A rise of 16 years in ex-

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pected longevity in only 40 years of elapsed time gives one occasion to pause and to think. Equally dramatic is the rise in median age of our population from 26.4 to 28.9 years in a single decade from 1930–1940. In 1900 only 17 percent of the total population had reached an age of 45. In 1940, 26.5 percent had passed the convenient meridian of 45. Conservative estimates by the United States Bureau of the Census, assuming no net immigration or emigration and ignoring the effects of the war, predict that in 1980 more than 40 percent of our people will be 45 years old or older. In the United States today there are more than 13 million people aged over 60, of which more than 9 million are 65 or older. The rate at which longevity is increasing was accelerated in the last census decade: from 1930 to 1940 our total population increased 7.2 percent, whereas the number of people 65 or older increased 35 percent in the same interval. The war will probably not alter the general trend significantly; deaths from battle casualties are counterbalanced by the quickened birth rate.

These trends were reflected in Industry well before the war. In the late 1930's one immense manufacturing corporation observed that the average age of its employees was increasing at the rate of a year per year. The shifts in population structure will continue after the war, and Industry needs to plan now how to best utilize the growing reservoir of potential accomplishment of the elderly. That they are capable of significant accomplishment is being demonstrated everywhere today. The tremendous withdrawal of young men from the farms and factories into the armed forces and the demand for gigantic production of the matériel of war has brought back into employment untold thousands of workers previously discarded as "too old." Just how many I do not know, nor does it matter greatly. Significant, however, is the undeniable fact that these older men and women, many far past later maturity and already in the years associated with senility, are laboring mightily, seriously, and effectively. Study of their production records will surely reveal that the former fearful attitude of management toward hiring employees past "the prime of life" was based more upon prejudice than factual data.

We cannot escape the obligations imposed by the ever increasing proportions of the elderly in our population. The elderly are here in unprecedented numbers, which will increase. If society fosters research and medical and hygienic practices for the prolongation of life, society must assume at least some responsibility for the lives thus extended. Certainly no one but another paranoid would advocate solving the problem, à la Hitler, by wholesale "liquidation" of the elderly. Business has but two alternatives: either to find and apply ways of employing older individuals in occupations and under conditions suitable to their peculiar capacities so that they may continue to earn their way, or to contribute more and more heavily toward payment of the mounting bill for their support, either directly as pensions, or indirectly and more expensively through heavier and heavier taxation for a "security" program already known to be actuarially insecure. The sane choice is obvious. We can expect little opportunity for individual saving for retirement in the face of present and impending taxation.

This is a gloomy picture, but as such is not a true one, for like the conventional cloud there is a very hopeful silver lining. The millions of people past their assumed "prime" constitute an invaluable, though previously ignored, human resource. They represent an immense potentiality of useful and creative accomplishment. Wise planning and guidance based on the growing scientific knowledge of the phenomena of senescence can develop their potentialities and minimize their limitations. The discoveries of pure science and their technological application, enthusiastically and profitably supported by Industry, have produced many previously unknown and often unsuspected forces and materials. These promise incalculable benefit to all. But the full development of man himself, in contrast to the physical world about him, has barely commenced. The wonderful potentialities of mankind can be discovered only in those fully mature. More men are growing old enough to think. Thus the alternative to economic chaos consequent to a growing population of unemployed and dependent senescents is the possibility of a splendid

cultural advance led by the wisdom of mature minds.

Obviously, Industry does not stand alone in being responsible for the solution of the general social problems created by increasing age. But industrialists, and particularly those executives concerned with personnel management, are in a uniquely advantageous position to lead the way. If Industry does not take the initiative soon and earn leadership by right of accomplishment, politicians will and chaos threatens. Once politicians discover the growing power of the vote of the elderly, we may anticipate legislation of a series of Utopian "schemes," each one wilder than those preceding and each calculated to purchase political support but blissfully ignorant of sound economy. There is also a dreadful hazard from the unscrupulous Bosses of labor, ever willing to obstruct honest effort. And honest effort is characteristic of senescent individuals, for the greatest tragedy and hurt of aging is the sense of uselessness when their services are discarded by society.

Industry thus has the powerful motivation of self-defense to exert itself in leading the way toward wiser utilization of the aging through development of their latent capacities and through energetic efforts to improve their physical health and effectiveness. Whether industrial leaders have the wisdom to encourage such efforts is a different question which only time can answer. Certainly the basic prerequisite to progress is comprehension of what the changes of senescence do to men and women. The general ignorance concerning the fundamental consequences of this universal phenomenon is sadly apparent. When we apply Artemus Ward's definition of ignorance as "not not knowing but knowing so many things that ain't so," the situation becomes downright dangerous. Let us not forget that we *all* age, whether we like it or not, and that senescence affects everyone who survives long enough.

What Aging Does

Aging is a part of living. To age is to change. The changes consequent to aging start at the moment of conception and continue until death. The rate of change is greatest in infancy and youth and diminishes continuously as we approach the limits of man's span of life. Each period of life reveals certain characteristics peculiar to the age. The man of 50 is not the same person he was at 30—he is not merely 20 years older. He is a different being, with distinct alterations in his body structures, functional capacities, and reactions. He will continue to change, though more slowly, from 50 to 60 and still more slowly from 60 to 70. Just as the child is not merely a "little man," the senescent is something more than just an "older man." The changes involve all the innumerable activities which constitute living. People of different ages do not think alike, they do not react to disease in the same ways, they vary in their vulnerability to adverse environmental conditions, and differ in their capacity to work.

It must be re-emphasized that the changes occurring during senescence are not all in the direction of diminishing efficiency, as is commonly assumed. Certain functional capacities increase as others decline. The rate of depreciation with age of different structures and functional reserves is decidedly variable. We do not age symmetrically. I am sure we all know of some old men with young ideas; physicians see many young men with old hearts. As muscular strength and speed of movement diminish, certain manual skills may improve with continued use.

Furthermore, no two individuals age precisely alike. Chronologic age, as measured by the calendar, must not be confused with biologic age, for the two are often widely divergent. People do not all live at the same rate. The rate of aging is determined by the rate of living. Biologic time does not necessarily parallel solar time. Thus among any group of fully mature individuals there are some who have aged prematurely and others who are both physically and mentally much younger than their chronological age would indicate. Unfortunately, the latter are in the minority, although most of us are convinced that we are ourselves younger than our years. But this is wishful thinking and careful analysis would find many of us older than our calendar years. Variability among individuals increases with age.

One of the major reasons for the increasing variation among individuals is that no

two people lead identical lives. Each has been subjected to different physical and mental insults, fatigues, infections, and intoxications in different sequences and in varying intensities. All the apparently minor vicissitudes of existence affect us and their cumulative effect is most significant. What we are today is greatly determined by what we did yesterday and what happened to us the day before yesterday. Youth has had few yesterdays and therefore reveals relatively little variation.

This is not the place to discuss in detail the physical and functional changes which take place in senescence. Certain superficial and obvious changes we all know. Gray hair, bifocal spectacles, wrinkles, and a less steady walk all of us can recognize as signs of aging. But these are superficial and insignificant changes. Our real concern is with the efficiency of the organism as a whole. There are many young eyes, not requiring lenses, which see very little because they were never trained to look. What goes on within the skull is more important than whether the roof be a polished dome or a shaggy thatch of hair. As age advances speed and brute brawn diminish. But another and valuable characteristic, endurance for the slow grind, increases. Youth wins the sprint races; marathons are won by what sport writers dub "old men." It is significant that our army training programs have shown it to be more difficult to develop endurance in "trained" athletes than in farm boys, or men from the mines, desks, and factories. Industry too needs men able to maintain a steady but not flashy pace. Appraisal of productive capacity is not simple or easy, and judgments based on superficial signs are often sadly fallacious. Man has many capacities and thus there are many mental as well as physical facets relating to evaluation of fitness.

The major hazards from disease in youth and early maturity are quite different from those encountered in late maturity and senescence. Though many diseases appear in persons of all age groups, the more common, more serious, and more disabling disorders of the two periods are of entirely different character. In the first half of life almost all sickness arises from without, either from infection or physical injury. These disorders begin abruptly, are florid and therefore readily discovered, and are characteristically self-limited. In most instances the causative agents are known. Thus specific measures for prevention or treatment are possible. The tremendous reduction in morbidity and mortality among the younger portion of our population, which has contributed so largely to the dramatic increase in life expectancy in the last fifty years, stems from these very characteristics noted above. Because the sources of most illness to which youth is vulnerable lie in their environment, "wholesale" measures to improve the environment have immensely reduced the frequency of disease. Modern sanitation, quarantine to protect individuals from contagion, and the significant developments of industrial hygiene have thus changed the pattern of the population. All those millions of children and youths who now do not die of diphtheria, small pox, typhoid fever, tuberculosis, and similar infective diseases have the opportunity to survive to senescence.

As senescent individuals they become vulnerable to entirely different disorders. The common health hazards of later years are characteristically endogenous; they arise from within and not from environmental factors. They are chronic, silent of onset, and characteristically progressive rather than self-limited. They do not tend to subside of their own accord as do the acute infections of youth. Control of environment, either in the home or at work, can have but little effect on the frequency and severity of such disorders as arteriosclerosis, diabetes, heart disease, cancer, or arthritis. Prevention and control of these disorders must be on an individual basis and not through "wholesale" measures. There is no anticipation that we may ever be able to prevent high blood pressure by quarantine or reduce the frequency of diabetes by sanitation.

Two aspects of the so-called "degenerative diseases" of senescence are worthy of special emphasis. In the first place their occult and insidious beginnings make for delay in diagnosis and therefore in the institution of treatment. To discover hypertension or diabetes early enough so that treatment is attended by maximum benefit, they must be hunted.

The rash, fever, and sore throat of scarlet fever are violent and noisy signals of trouble. It takes little skill to discover such acute illnesses. But degenerative disease begins slowly, often without subjective symptoms, until irreparable and irrevocable damage is done. Secondly, the characteristic of progressiveness of these disorders is profoundly significant. Though progression in hypertension, arthritis, and arteriosclerosis is often very slow, it is always persistent. As a result, progressive and prolonged disability is the common sequence. Mortality figures can be badly misleading. For example, arthritis rarely kills, but it disables millions for many years. The arthritic becomes partially disabled in his late forties and lives on for twenty or thirty years, increasingly helpless, pathetically useless, and a constant drain on both his family and society. The economic aspects of chronic, progressive disease constitute one of the most urgent reasons for energetic attack upon the health hazards of later maturity.

Industry's Concern

Industry's concern with these particular facets of the broad problem is twofold: it must recognize the importance of early discovery of progressive disease in older persons and assist industrial medical services in such discovery; and it must realize that before severe disability makes continued employment impossible, there is usually a long period of impaired efficiency, which may arise so insidiously that it is not recognized. Mild chronic illness is a significant element in the important problem of sick absenteeism. Continued assignment of responsible tasks to individuals gradually becoming more and more unfit to perform them introduces a double hazard; for the individual it creates stresses which tend to accelerate his depreciation and for Industry it invites expensive failures in performance. Many business disasters could be traced to arteriosclerosis in executives. On the other hand, the early discovery and prompt institution of proper medical management of diabetes may conserve for Industry many a fine, precious, and useful mind.

Industry is in business to earn money. This means that it is interested in saving money too. Industrial health programs are not primarily altruistic. They are basically concerned with reducing the heavy costs of injury to personnel occurring in the course of employment and checking the loss of production from absenteeism due to illness arising independently of work.

The first leak is being reduced through the triple activities of industrial hygiene, safety programs, and more effective medical and surgical repair and rehabilitation services. The second leak is the more serious, although its importance has been appreciated only recently. In loss of time, and therefore in loss of production, sickness absenteeism of non-industrial origin is about fifteen times more serious than injury arising from employment. But basing loss from impaired health only upon actual absenteeism reveals only part of the picture. Probably equally expensive are the additional and unmeasured losses in production due to impaired efficiency of personnel not sick enough to be absent but who accomplish but a fraction of what they should be capable of doing if their health were optimum. For every employee absent because of illness, there are probably a dozen present who, because of impaired health, merely go through the motions of doing something. Among these are the conscientious fools with acute respiratory infections, generously spreading infection among their co-workers. Included also are many with chronic unrecognized and untreated disorders. In general the frequency of impairment, as measured by reduced effectiveness, is in inverse proportion to the severity. The ways and means of discovery and correction of the minor, early, chronic impediments to full vigor, health, and efficiency are closely related to and parallel those procedures required for the full utilization of senescent individuals. It will be worth while to remember that the implications of the concepts to be suggested in the remainder of this article are not limited to older persons.

(To be concluded)

THE FENCE*

By HOWARD B. ADELMANN

It is with some trepidation that I, a worker in the sciences, venture to address you, my friends and colleagues on the humanistic side of the academic fence. Ordinarily, by an unwritten, but unfortunately, too widely observed agreement, you "humanists" cultivate only the fields on your own side; we "scientists" labor only on the other. Standing on my side of the fence, I have often hung upon it in friendly converse with you, and I have enjoyed the experience so long as I felt myself protected by that intangible barrier. But now that you have lifted me bodily over it, so to speak, by inviting me to come among you, my emotions are confused—on the one hand I feel the pleasure and the satisfaction of more intimate association with you, and on the other, I am fearful of exposing my inadequacies.

Unlike that distinguished but lovable gentleman, Hieronymus Fabricius of Aquapendente, who was three centuries ago Professor of Anatomy and Surgery in the University of Padua, and in whose company I have spent, most pleasantly, much of my time these past few years; unlike him, I say, I do not dare to promise you, as he once promised an audience, a discourse *absolutissima, fructuosissima, luculentissima.* His listeners went away muttering *imperfectissima, obscurissima,* and so indeed may you, despite the fact that I make no promises. At any rate, you will probably say with perfect justice, as his students did of some lectures they forced Fabricius to give: *ut coacta, ita admodum exigua;* which means, as you all know, "being compulsory, it was therefore pretty thin."

I was very glad to learn a few years ago that the Cornell Chapter of Phi Beta Kappa had decided to admit superior students whose interests lie predominantly in the laboratory sciences. Who knows? Perhaps the fence is being torn down. It did not always stand; its construction was begun long ago when a few scholars commenced to work intensively in the natural sciences, and, after both sides had worked at it diligently for some two centuries, it had reached by the nineteenth very nearly the proportions of a spite-fence. It should never have been erected; it was illegal to begin with, and unsightly and unneighborly at best.

The restricted application of the term "scientist" to workers in the natural sciences and mathematics, as is the common practice these days, is inaccurate and unsound, historically and linguistically. By what right have some scholars been dubbed scientists, a name which implies that they alone have the key to knowledge? By what right have other scholars been called humanists, a name which implies that they alone are the custodians of the forces that make a man more humane, more civilized, more exalted? There is, in truth, no essential difference in their aims: both strive to reach an understanding of man and the world he lives in; neither is the exclusive custodian of civilization, culture (or whatever you choose to call it), or of knowledge and the means to obtain it. Both may, indeed, sometimes use the same methods. "It is simply the fact," I quote Professor Lane Cooper, "that reduced to the simplest terms, there is but a single method of investigating the objects of natural science and the productions of human genius. We study a poem, the work of man's art, in the same way that Agassiz made Shaler study a fish, the work of God's art; the object in either case is to discover the relation between form or structure and function or essential effect."

And neither the so-called sciences nor the so-called humanities are by themselves adequate for man in his pathetic attempt to understand himself, his fellow man, or the world he lives in. The knowledge that I am made of organs, tissues, and cells; that these in turn are composed of carbon, hydrogen, oxygen, nitrogen, and a miscellaneous assortment of other elements, themselves

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owing their properties to the configuration of their atoms, electrons, protons, and neutrons is illuminating, even inspiring in its way. But it is not enough. Will Einstein's treatise on relativity increase my wonder at the magnitude of the universe? If I am moved by the grace and beauty of the flight of a bird will my exaltation be sustained by a handbook of the birds of central New York, or, on the other hand, by some poet's insight? Will a so-called "scientific" treatise on art explain the emotions aroused by beauty in whatever form?

My fellow man—will so-called science explain him completely? Must I not also, at the very least, have some knowledge of his language, his literature, and his history?

And the universe—can science explain it all? I ask *you*. At the present time the hope that both camps working together will some day explain the universe even partially seems almost presumptuous.

The truth is that a diet of straight science is unsatisfying. Karl Ernst von Baer, whom we honor as the founder of modern embryology, and who, like most great men, was modest, tells of his experience after he had labored for the better part of a year, shut up in his laboratory, at his studies on the development of animals. He had started work when snow lay upon the ground, and when he finally emerged from his self-imposed imprisonment he found the grain in sheaves. "This sight moved me so deeply," he says, "that I threw myself upon the ground and reproached myself for my foolish behavior. The natural laws of development will ultimately be discovered . . . whether by me or by others, whether this year or at some future time is relatively unimportant, and it is utter folly to sacrifice to this end one's own joy in Being which no one can replace."

We scientists, I think, are peculiarly apt to lose our sense of proportion. We describe a bug not previously recorded; we make an experiment never performed before; and our discoveries are so exhilarating that we are apt to magnify our own importance, and like Aesop's fly resting on the axletree of a chariot wheel, marvel at the cloud of dust we raise. We need the corrective of history and literature, which gently teach us our proper place. The scientific journals of yesterday are gorged with the papers of scientists who were no doubt "big" men, "productive" men in their day. One imagines that they were deluged with "offers," and that they basked in the prestige that loquacity in print often brings. But they are unknown to fame; the once mighty have fallen. It is no discredit to them; they have contributed their mites.

On the other hand, it is encouraging to know that the humble sometimes rise. Think of Gregor Mendel, regarded, perhaps, in his day as a harmless putterer in the monastery gardens at Brno, and now paid tribute as the founder of modern genetics.

Now whether or not the humanities undefiled are an adequate diet for the mind, you will know better than I. I shall merely ask, and having said *peccavimus* for the scientists, leave you, if it is in your heart, to do so for the humanists.

As I have said, the imaginary fence between the scientists on the one hand and the humanists on the other did not always stand. In what I like to think of as better days, philosophy, art, and science were not differentiated. The emphasis then was upon knowledge, and all departments of knowledge were called upon to contribute their fair share to a unified system aimed at the comprehension of all phenomena.

The works of Aristotle, for example, contain something of value for workers in almost every field of knowledge. For some of you he is one of the greatest authorities in the art of poetry, others of you have, no doubt, found much of permanent value in his works on rhetoric, ethics, politics, logic, or metaphysics. As a biologist Aristotle has had his detractors, but for me, as for others, he is the greatest biologist that ever lived.

D'Arcy Thompson, a classical scholar as well as a scientist, says that Aristotle seems to have been "first and foremost a biologist, by inclination and by training," and Jaeger, a classical scholar, indicates that Aristotle's true genius lay in the field of biological science. It is, at any rate, surprising to find how large a part of his writings deals with biological problems, a fact sometimes overlooked by those who are interested in other aspects of his work.

Some scholars believe that the zoological works were composed during the period of Aristotle's second stay in Athens, say a dozen years preceding his death. Others, however, believe that the philosopher's biological studies were begun at Lesbos about ten years before he began his teaching in the Athens Lyceum. And the evidence does seem to show that his most important observations were made on the Asiatic coast and in the vicinity of Mitylene on Lesbos.

There are three aspects of Aristotle's biological works upon which I should like to touch briefly—first, the range of his zoological knowledge; second, his profound grasp of the essential problems; and third, his method of investigation.

Aristotle was acquainted with a truly astonishing number of animal forms. Some of them, particularly marine animals, he knew rather intimately, others only superficially. Some he appears to have dissected, others he peered into as we do in preparing a fish or a fowl for the table. When I say dissected, I do not mean that he dissected systematically or thoroughly—he would, no doubt, have done a better job with a modern manual for dissection at hand. He came to the study of animals untutored; many structures he overlooked, and many he misinterpreted because his mind and eye were not prepared to grasp the significance of everything he saw; but on the whole his knowledge is of such a character that it is difficult to believe that all of it was derived from talking with fishermen, hunters, or butchers, or that he was merely a passive observer of work performed by students.

D'Arcy Thompson marvels at Aristotle's rather intimate knowledge of marine molluscs, and, as many others have done, calls attention to one remarkable observation which was not substantiated until the nineteenth century, after several observers had completely misinterpreted the true state of affairs. In both the *Historia animalium* and the *De generatione animalium* Aristotle describes the peculiar transformation of one of the arms of the male octopus into a sperm-bearing organ which is detached after it is placed in the mantle cavity of the female. This detached arm was rediscovered in 1828, called a parasite, and given the scientific name *Trichocephalus acetabularis*. Later, Cuvier described it as *Hectocotylus octopodis*. Kölliker, the distinguished Würzburg anatomist, regarded it as a parasitic male similar to the diminutive males found in certain other animals, and it was not until 1851 that the French naturalist Vérany fortunately discovered that the supposed parasitic male is really one of the arms of the male octopus. Finally, in 1894, Racovitza's observations on the mating of the octopus completed the confirmation of Aristotle's description.

Aristotle's knowledge of fishes is another aspect of his work that has aroused the admiration of commentators. For example, his description of the various types of cartilaginous fishes, that is to say, the sharks and rays, was a real achievement. He knew that some sharks lay eggs and that in some the eggs are retained in the oviduct of the female until the young fish are ready to fend for themselves. Until it is able to capture food an embryo shark lives upon the yolk stored in the egg; this yolk is contained in a sac, the yolk sac, which is attached to the intestines of the embryo by a long stalk, called the yolk stalk. Aristotle knew this, and he knew, further, something that zoologists did not generally know until 1840. He tells us that in the smooth shark the young develop with the yolk sac attached to the wall of the oviduct, "so that as the egg-substance gets used up, the embryo is sustained to all appearances just as in the case of quadrupeds." In other words, Aristotle recognized the placental character of this union of the yolk sac with the oviduct or uterus. At the point of contact the embryonic and maternal tissues are highly vascular and inter-folded so that an interchange of substances between mother and fetus becomes possible. Such an arrangement is now called a yolk-sac placenta, to differentiate it from the type of placenta found in mammals. In some mammals, however—the horse, for example—a yolk-sac placenta essentially similar to that of the shark's is found in addition to the usual type.

Aristotle's observation of the yolk-sac placenta of the shark was confirmed by the great Danish scientist Niels Stenson in 1675, whose description was published in a

relatively obscure journal, the *Acta medica et philosophica* published at Copenhagen. Buried there, Stenson's contribution was completely overlooked, and it was not until 1840 that Johannes Müller again called attention to Aristotle's original description and confirmed it by his own investigations.

As an embryologist, I am naturally interested in Aristotle's account of the development of the chick. I shall not tire you with an analysis, but say merely that it is the work of a really acute observer and a highly creditable achievement.

There is no time to continue this sketch of Aristotle's knowledge of fact, nor can I discuss in detail his attack on the major problems of zoology. He did think wisely and soundly about many of the fundamental issues; but obviously it would be stupid to expect solutions of them, or twentieth century analyses, from an author who lived so close to the very beginnings of scientific endeavor. We are still working at the answers to almost all of them.

One of Aristotle's theories, however, shows so clearly what E. S. Russell calls the "sheer intellectual power" of the man that I cannot pass over it. That he was able to formulate, in the necessarily imperfect state of his own knowledge, a theory of development that conforms closely to our modern point of view is, I think, noteworthy. He rejects the idea that the embryo is preformed from the moment of conception and argues brilliantly that the parts of the embryo are only gradually evolved as development progresses. This so-called doctrine of epigenesis is usually associated with the name of William Harvey, the discoverer of the circulation of the blood, but Harvey obviously was indebted directly to Aristotle.

And now a word about Aristotle's method. The biological treatises reveal a complete shift of emphasis in contrast to the others. In his earlier works Aristotle emphasizes the deductive, syllogistic approach to knowledge, but in his biological works he stresses the basic importance of observation, of observation as the starting point in the acquisition of knowledge. This change of emphasis has often been overlooked. The first of his three great zoological works, the *Historia animalium,* is essentially descriptive in character, dealing primarily with the material cause; the second, the *De partibus animalium,* elucidates the final cause, the good purposes displayed in the structure of animals; while the third, the *De generatione animalium,* is a treatise on the efficient causes of development, the forces which bring animals into being.

It is interesting to notice how this emphasis on observation and this general plan of treatment influenced later writers. Galen, for example, teaches as an invariable rule that one should dissect and describe before attempting to ascertain the action or the useful purpose of an organ. In his works on anatomy and physiology, Fabricius in the sixteenth century invariably stresses the importance of the same order of treatment and cites Aristotle and Galen as his models. Sir William Harvey, the pupil of Fabricius, quotes Aristotle as his authority in urging observation and admonishes us to trust nothing but our own eyes, to accept nothing not "securely bottomed by the faithful testimony of our own senses." "It is unsafe and degenerate," he says in the Preface to his *Anatomical Exercitations* in 1653, "to be tutored by other men's commentaries . . . when the book of Nature is so open, and legible. The ancient philosophers went quite a contrary way to work, and by in defatigable [sic] toile . . . have set up a clear light to direct our studies. So that whatever notable and approved thing we have in philosophy, it all is derived to us by the pains and industry of ancient Greece." And he further tells us that "in chief, of all the ancients, I follow Aristotle."

Now, I am no philosopher. I cannot argue for or against the validity of observation as the basis of scientific procedure. I only know the feeling of most present-day workers. If they were questioned, I am sure that they would, almost to a man, rightly or wrongly, scientifically or unscientifically, urge observation as the indispensable approach. And I know that it is easy to trace this emphasis on observation back through the years to the seventeenth and sixteenth centuries when many men thought, rightly or wrongly, that in urging observation they were following in Aristotle's footsteps. Thence the path follows back to the resto-

ration of Aristotle to Western Europe in the late Middle Ages.

In physics Aristotle's standing is not high; mathematics he virtually ignored. But, even in these connections, I wonder if too much has not been made of the so-called revolt against Aristotle—of the revolt of Galileo, for example, of whom J. H. Randall says, "in method and philosophy if not in physics he remained a typical Paduan Aristotelian." Francis Bacon justly attacked Aristotle's reverence for final causes, and his vision of a science based on experiment is a noble one. But listen to Bacon's statement in the *Sylva Sylvarum:* "Aristotle," he says, "giveth the cause, vainly, why the feathers of birds are of more lively colors than the hairs of beasts,—for no beast hath any fine azure, or carnation, or green hair. He saith it is because birds are more in the beames of the sun. . . . But the true cause is that the excrementitious moisture . . . passeth in birds thru a finer and more delicate strainer than it doth in beasts; for feathers pass thru quills, and hair through skin." Hardly an improvement on Aristotle's explanation!

It is, as both Olschki and Randall have noted, probably a mistake to accept at face value "the estimate the pioneer thinkers of the sixteenth and seventeenth centuries made of their turning away from the heritage of the past."

I have dwelt on Aristotle as an example of a thinker whose interests embraced all knowledge. But I realize full well that we can never return to the day when a man could have respectable competence in a great number of fields. We cannot revisit yesterday, or ask even the fleeting moment to delay. Knowledge has grown too vast for one man to digest it all, and a minute knowledge of one field, indeed, of even a small corner of one field, is often difficult, sometimes impossible, to master.

Specialization can be, however, and has been, in some instances, carried too far and without tangible profit to the individual or to science. As in the past, catholicity of interest even today has its values.

I like to think of those physicians who in the fifteenth and sixteenth centuries did so much to restore the great texts of ancient learning to the enjoyment and profit of man—of Linacre, for example, the physician of two Henrys, VII and VIII. He was one of the first English physicians to study at Padua, the great stronghold of Aristotelianism. It is said that the noble Aldine *Editio princeps* of Aristotle was, in part at least, edited or corrected by him. When he returned to England he taught Greek and practiced medicine at Oxford. More and Erasmus were his students and so were two children of Henry the uxorious. He translated much of Galen into Latin. He was a distinguished grammarian, and Fuller, the historian, says that it "is questionable whether he was a better grammarian or physician." His masterpiece, the *De emendata structura Latini sermonis*, has been called "the first-fruits of English erudition." But Milton says, "Though very learned it is thought not fit to be read in schools." What an apt characterization of some contemporary texts!

Coming down the years, and ignoring many I might recall to you, I think of Albrecht von Haller, the great eighteenth-century Swiss from whose facile pen poured the first modern textbook of physiology; distinguished works on anatomy, surgery, embryology, and botany; bibliographies that are models not yet superseded; and finally, poetry that is still admired, for editions still come from the press.

In our own day there was Sir William Osler, Professor of Medicine at McGill, Pennsylvania, and Johns Hopkins, and from 1905–19 Regius Professor at Oxford. He was the author of one of the first literate textbooks of medicine, and the world was amazed that a physician could write the English language with lucidity and grace; amazed when he introduced into his discussion of tuberculosis the parable of the Sower, or quoted Sir Thomas Browne, or showed in any small way that he was familiar with something more than the bare bones of technical literature. And is that amazement not in itself significant? Osler loved the literary classics, was himself learned in them, and in 1918 was honored by election to the presidency of the Classical Association of Great Britain. Throughout his life the *Religio Medici* of Sir Thomas Browne was a constant

companion, and the copy he had bought as a boy was placed in his hands when his remains lay in state. In his essays he never ceased urging physicians to consult with the great minds of the past while they themselves pressed forward. His methods of medical teaching were unquestionably responsible for the reform which began to affect our medical schools shortly after 1910. His beneficent influence still persists, and no doubt lies back of the emphasis the officials of our medical schools now rightly place on broad cultural training in preparation for medicine. But, alas, they think that culture, so-called, can be acquired from formal courses in college! And, alas, too, they do not realize that they must themselves set an example. The teacher says, "Look at Osler." And the student, too often, unfortunately, can reply, "Yes—look at Osler. But you, dear teacher, are not an Osler, and yet, by specializing narrowly, you have acquired a far larger share of this world's goods than he. Rumor says that you clean up an appalling sum in private practice, and this advice to shun the fleshpots, to cultivate the gardens of the soul, comes ill from you."

And in the so-called pure sciences a teacher who admonishes his students to acquire even so elementary and useful an accomplishment as the ability to read a modern foreign language without too frequent recourse to a dictionary is, as likely as not, met with the retort: "Look at Professor Gamma. He reads French and German with, to put it as kindly as possible, the greatest of difficulty—I know, because I took my language exam for the doctorate from him—yet he is respected as the world's greatest authority on the tenth cranial nerve of Ornithorynchus."

How can one reply without transgressing professional ethics?

Convincing the modern gradute student of (let's say) histology how important an asset some historical knowledge might be, or teaching a little history of biology along with modern developments, takes a deal of persistence, even bravery, under present circumstances. And, yet, I think we scientists must begin to teach in our classrooms respect and sympathy for those disciplines that now are often regarded as foreign to our interests. We must do it by calling upon philosophy, history, and literature where they impinge upon our work. I know of no department of science where such treatment would not stretch the vision and deepen the understanding.

And now, dear humanistic scientists, how about a little natural science in *your* classrooms? How about the history of science? How about some Hippocrates, Aristotle, and Galen in Greek? How about some Latin from the scientists of the sixteenth, seventeenth, or eighteenth centuries; in French, some of Pascal's scientific, in addition to his purely literary, works; or in German, let's say the autobiography of Karl Ernst von Baer? I think I know at least two good objections you may raise—lack of time and the lack of literary merit in some of the works I mention. But can you not compromise? It would, I think, be for your good as well as ours.

This war is going to send our young people back to you in larger numbers than of late. They are going to return to you surfeited, sick unto death of technological and scientific detail. They will, many of them, thirst after the good things, the human values, you can offer them. There lies the chance you may seize to the everlasting benefit of us all. In this modern world, however, no man can well get along without an awareness of the great technological and scientific advances of our age. We must work together to destroy the fence that has, to our common disadvantage, kept us apart, or at least provide friendly and inviting portals through it. It is for us both to show the student that the humanistic and natural sciences together form a part of the heritage he ought to embrace in justice to himself and for the good of the world.

MIRACLES? . . . MAYBE

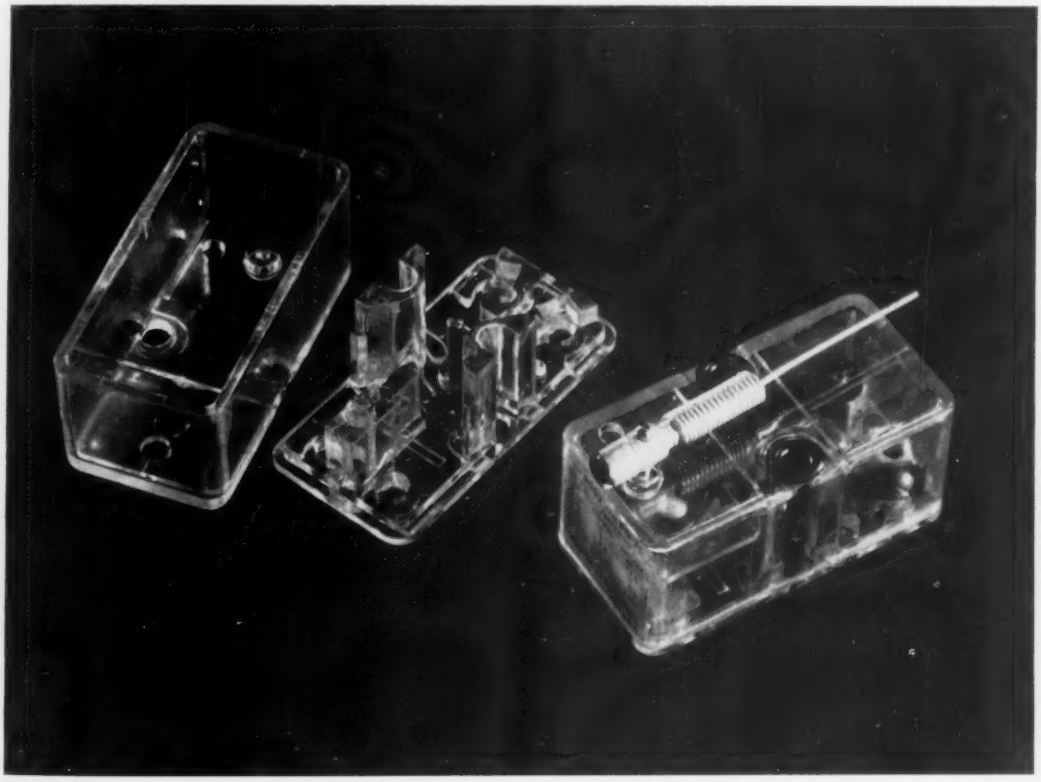
By L. H. WOODMAN

"Plastics will revolutionize living." "A miracle age of plastics is just around the corner." "In the plastic world ahead many common metals will become obsolete."

Whether such statements, which are unfortunately typical of many seen and heard from day to day, represent an attempt to startle the public mind to attention through the inherently magnetic power of the fantastic, or simply misguided over-enthusiasm is a moot question. It is certain, however, that they do not represent the real opinions of sound-thinking designers and engineers, nor of the dozen or more reputable companies which are now supplying the major portion of the plastic materials being produced in this country.

First of all let us see what plastics are and from whence they come. To the average individual the term may well bring to mind a gadget purchased in a variety store, a piece of costume jewelry, or the streamlined cabinet of a small radio. He does not necessarily associate the term with high quality; in fact he may well regard articles made from plastic as ersatz—something to be worried along with until more common materials are once more obtainable. He has, however, been quite thoroughly educated to expect that in the months following the war a host of new materials, little short of miraculous in their beauty and qualities, will make their appearance.

To the chemist, these materials, which for the most part have their origins in coal, petroleum, brine, or vegetable fibers, represent



TRANSPARENT SWITCH BOX MOLDED FROM POLYSTYRENE
ITS EXCELLENT ELECTRICAL PROPERTIES RECOMMEND IT FOR SCORES OF POWER AND RADIO APPLICATIONS.

PLASTIC-COVERED CHAIR

SARAN RATTAN AND FABRICS FROM FINER FILAMENTS PROVIDE DURABLE UPHOLSTERY FOR MANY PUBLIC USES.

a fruitful field of exploration for years to come—a field holding great promise both for the improvement of formulas and methods for making existing plastics and for the discovery of synthetic materials not yet envisioned by even the most imaginative chemist. This is apparent partially because many plastics are polymers.

Polymerization is a term applied to the linking together, in a definite pattern, of two or more molecules of a substance (monomer), resulting in a chemically identical but physically different substance. Since each polymer containing a different number of molecules in linkage, or perhaps the same number of molecules but linked in a different pattern, may possess unique properties, it is seen that literally millions of such polymers are possible. This does not mean, however, that millions of plastic materials are conceivable or possible, but it does indicate the field of exploration which is open to the chemist.

Commercial development of these polymers has been partially a matter of determining what stimulus was responsible for a particular type of polymerization and of learning to control that stimulus so that the same polymer would result each time it was applied. The stimulus may be temperature, light, pressure, various catalysts, or a combination of several factors. Of even greater importance in this development has been the achievement of consistent purity in the monomers from which these polymers are derived.

Other plastic materials result from the compounding of two or more chemical substances under certain conditions, and here again is a broad field for future development.

While plastics as structural materials are relatively new, crude or impure forms of some of these resins have been laboratory curiosities for many years. For example, the history of the vinylidene chloride polymers dates back as far as 1838 when a chemist named Regnault reported the formation of a white, nonerystalline precipitate from a liquid boiling between 35 and 40 degrees Centigrade. The liquid was apparently an impure dichloroethylene.

Later, about 1872, other experimenters found a similar substance which polymerized in light to a white, amorphous mass, which was found to be insoluble in many solvents. Extensive work on these polymers, however, has been limited to the last decade, and this family of resins known as *Saran* was not introduced to the plastics industry until 1939.

A similar history is found in the case of crystal-clear polystyrene. The styrene monomer was first isolated in 1831, having been produced from the distillation of a purified form of balsam known as storax. Its

TRANSLUCENT *SARAN* TUBING

ADVANTAGES OF THIS TUBING OVER COPPER AND OTHER TYPES ARE FLEXIBILITY AND CHEMICAL RESISTANCE.

thermo-polymerization in the presence of sunlight was noted some eight years later, but it was not until 1869 that the ethyl benzene process for making styrene was discovered by the French chemist, Berthelot.

The first recorded patents disclosing possible uses of styrene were granted in 1911 to F. E. Matthews of London, who observed the excellent insulating qualities of polymerized styrene. In the succeeding years polystyrene molding powders gradually gained popularity in Europe. In 1937 The Dow Chemical Company introduced *Styron*, a high purity polystyrene, in this country after years of intensive research in developing a controlled production process which assured uniformity and overcame certain other major obstacles that had held back the commercial development of these resins.

Such case histories are by no means rare among these so-called *new* plastic materials. Like many modern chemical finds, they have resulted in their present form not from scientific hocus-pocus or chance discovery, but rather from the painstaking, but imaginative, research of several generations of scientists.

That the product of such efforts in many cases should have been introduced to the public in the form of trinkets, or in applications where the properties of the plastics could not be fully utilized, is somewhat regrettable. Polystyrene, for example, is one of the most efficient organic electrical insulators

SARAN THERMOPLASTIC PIPE

A PIPE BASKET FABRICATED FOR USE IN PICKLING BATHS FOR SURFACE FINISHING OF MAGNESIUM PARTS.

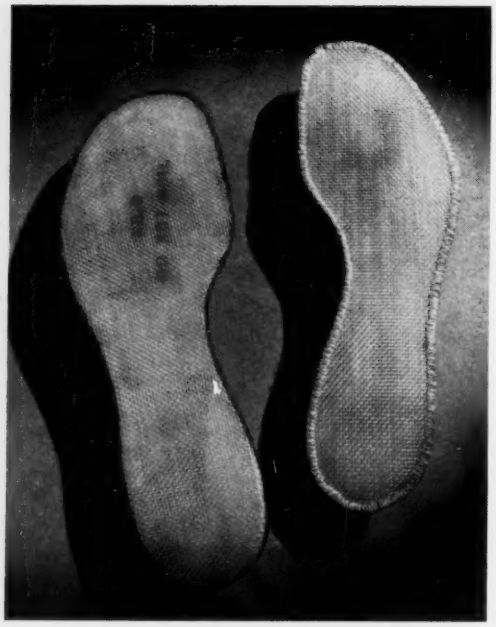
UNAFFECTED BY ACIDS

THE LADLE BEING USED IS MADE OF *SARAN*, ONE OF THE MOST CHEMICALLY-RESISTANT OF ALL PLASTICS.

ever discovered. This property alone is of vast importance to radio, power, telephone, and allied fields. But it has many other admirable characteristics. It is among the lightest of all plastics, having a specific gravity of only 1.06. It does not absorb water and is highly resistant to most acids and alkalies. It can be produced in all colors of the rainbow or in such crystal clarity that optical lenses are being made from it.

Obviously, polystyrene makes an exquisite string of beads or a beautiful lamp base, and there will be plenty for such uses, but its characteristics portend many more important applications. It will add beauty to our lives through purely decorative functions, but it has a far greater destiny in adding safety, comfort, and convenience through applications that will be less apparent but more fundamental in their importance. The styrene monomer itself is at present a vital component of Buna S, a synthetic rubber.

So it is also with *Saran*. This versatile family of resins appears in an amazing number of forms—as a chemically-resistant black pipe, or a yellowish, translucent, flexible tubing; as a clear, tough, moistureproof film; as a spongy, rubberlike substance that may in



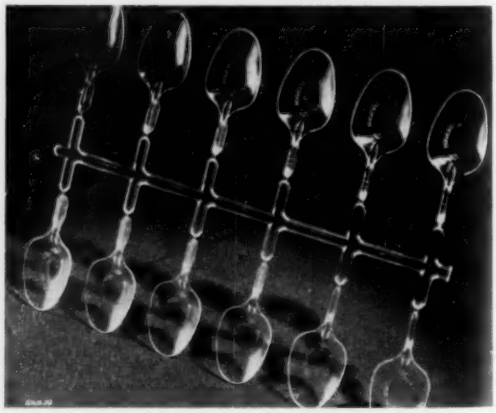
HYGIENIC *SARAN* INNERSOLES
MADE OF LAYERS OF SCREENING WELDED OR SEWED AT EDGE, THEY ARE RESILIENT, NONABSORBENT, WASHABLE.

the future be used for shoe soles, tubing, perhaps even tires or inner-tubes; as a colorful, moisture-resistant, long-wearing fabric; as a variety of molded or extruded shapes; as a flexible screening material that will neither rust nor corrode.

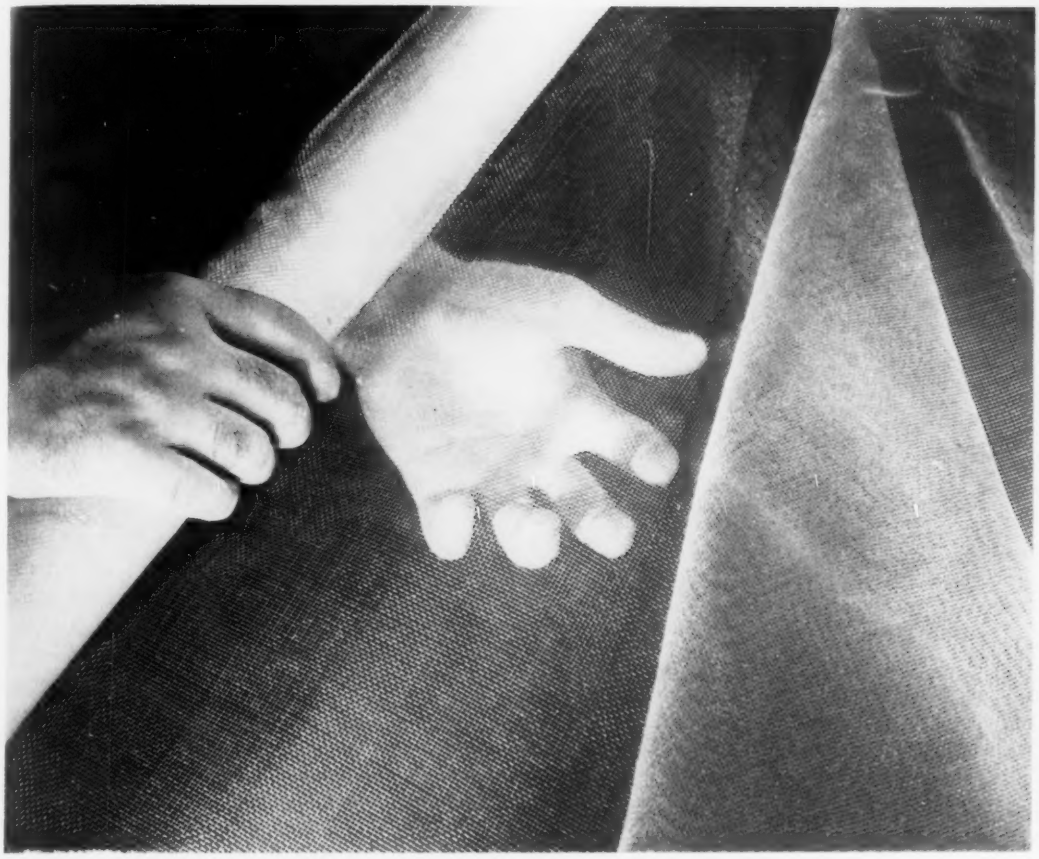
Like polystyrene, *Saran* has its decorative applications. Before the war, belts, suspenders, and other clothing accessory items were woven from colorful monofilaments of the material. As a matter of fact, *Saran* made very good belts and suspenders, but its properties cast it in far more vital roles. Since is it one of the most chemically-resistant plastics, it will be widely used in forms such as pipe and tubing to replace copper, steel, iron, and other metals in a host of industrial applications where chemical action upon the metal has previously made frequent replacement necessary. As a film it now protects machine guns against damage by moisture during shipment; in the future it will lend this protection to foodstuffs, clothing, metal parts, and equipment for civilian use. As a synthetic rubber it may find ready acceptance for use under conditions which deteriorate natural rubber rapidly. As a colorful fabric it will lend its exceptional wearing qualities to upholstery materials for automobiles, theater seats, bus and train seats, and other installations where excessively hard use is encountered. As a screening material it will add beauty, cleanliness, and convenience to the home, factory, or public building.

These are thumbnail sketches only, and when it is remembered that there are already more than a dozen basic plastic materials of proven worth, many of which have multiple applicative personalities, the tremendous scope of these products of chemistry may be appreciated. If we attempt to say, however, that plastics will completely revolutionize living, speak of them as "miracle" materials, or suggest that common metals will become obsolete, we are making bold and probably fanciful predictions. For countless uses the older materials will continue to remain the most suitable, and only where a plastic can prove itself more advantageous than any other material can it hope to gain and maintain precedence in the field of public acceptance.

Plastics are not cure-alls or all-purpose materials any more than are wood, glass, leather, or steel and other metals, and they are subject to the same tests of worth. In considering a plastic as opposed to a nonplastic material, and in selecting from the many types of plastics available, the industrial engineer must ask the same time-tested questions: What is the cost of this raw ma-



MULTIPLE INJECTION-MOLDING
TWELVE MEDICINAL MEASURING SPOONS ARE MOLDED FROM POLYSTYRENE IN ONE SET OF REVOLVING DIES.



INSECT SCREENING WOVEN FROM *SARAN* MONOFILAMENTS
IT IS LIGHT, HIGHLY FLEXIBLE, RESISTANT TO CHEMICAL FUMES AND SALT AIR AND TO ATTACK BY FUNGI.

terial? What will be the cost of fabricating it into the finished article? Are there complicated production factors involved? To what extent will the use of this material necessitate the installation of new and expensive equipment or involve the acquisition of specially trained men? And finally, will the finished product, made from this material, be a better product for its intended use than a similar one made from another material? Or will it be equal in quality and performance and still enjoy advantages in the way of production economies?

These questions might be said to represent simply the major titles of the "examination." Within them are hundreds of minute technical questions. The acceptance or rejection of a particular plastic, or of plastics as a group, depends upon a careful weighing of the answers. Failure to consider all points involved, and in proportion to their relative importance, may well result in an embarrassing misapplication of a very worthy material.

Many plastics, for example, lend themselves well to the injection-molding process of fabrication. This automatic or semi-automatic process is an extremely economical production method. Plastic material is injected, through a mouthpiece or jet, into a set of dies. The dies are so made that from one to a dozen or more pieces may be molded at a single "shot," and several sets of such dies may be mounted in a revolving turret, so that while the molded pieces are being ejected from one set, the plastic is being injected into another set. With such equipment the production of several hundred small parts per minute is readily accomplished.

In the face of such production economies it is apparent that there may well be some temptation to utilize plastics in applications

USING A PLASTIC CANTEEN

MADE OF ETHYL CELLULOSE, THIS CANTEEN IS LIGHT, ODORLESS, TASTELESS AND WITHSTANDS HARD SHOCKS.

for which they are not ideally suited. Correctly applied, however, these production economies open the door to a host of low-cost plastic articles which will equal or exceed in beauty, utility, and performance similar products made from more costly materials or by more expensive methods.

While war necessity may have forced certain plastics into applications where their performance is by no means exceptional, it is at the same time serving as a gigantic and stern proving ground for plastics of all types. A number of plastic materials have for some time occupied a position akin to copper, brass, steel, and other metals on the nation's "critical" list. With the broad range and exacting requirements of military plastics, the knowledge and experience being gained today should leave little doubt in the minds of those associated with the industry as to the correct and incorrect applications of most of these materials. It will be the function of these men—the responsible manufacturers, designers, and engineers—to use this knowledge wisely in building the postwar plastics industry upon the substantial foundation of fact rather than on fancy and fadism.

These men know that plastics, properly applied, are truly amazing materials. But they also know that there never has been, and never will be, a material perfect for all purposes. Under competent development plastics are already graduating from the gadget stage into their rightful position as tools of industry and science in their continuous progress toward a better and higher plane of material civilization.

Miracle materials? Yes—if steel, glass, and cotton are also miracles. Each must have seemed equally miraculous when technology first brought it into view. Revolutionize living? Probably to a considerable extent, but not necessarily in the spectacular manner that many people have been led to expect—at least not immediately after the war. Widely assorted plastic articles should be available in plenty, but the more spectacular proposals—plastic auto bodies, plastic houses, plastic flivver airplanes—if they come, will develop more slowly. Meanwhile, plastics will play their more vital role behind the scenes through industrial applications that will constitute unseen but determining factors in our evolution toward better living.

THE FORBIDDEN LAND*

By MARY ELLEN GOODMAN

For the nomadic peoples of Tibet, life is chiefly regulated by the character and potentialities of their domestic animals. Their herds include sheep, long-haired goats, horses, and yaks. All save the last prefer to feed on grass in the stream bottoms; the indigenous yak wanders up the hill slopes after moss. He is a slow feeder and, when utilized as a pack animal, must be freed at night; as C. Suydam Cutting has remarked, the yak must be "allowed to wander at will, with the result that a good two hours must be spent in the early morning in collecting the yaks and loading them before a caravan can move." Although much slower than the horse—he travels about two miles an hour—the yak is ideally suited to the region because of his heavy coat and his ability to feed on limited materials and to carry packs of as much as a hundred and seventy pounds. In western Tibet sheep and goats are also utilized as pack animals. They carry twenty to twenty-five pound loads and may be slaughtered at the end of the journey.

The pastoralist moves with his animals when pasturage is exhausted and when seasons change. Maximum summer temperatures allow him to move north and west and to higher elevations, while with the dropping of the temperature he works his way down until in mid-winter, with his grain supplies nearly exhausted, he makes his way to Lhasa or another urban center where he may stay during the most bitter weather. Lhasa and Shigatse are the chief centers of trade in central Tibet; Cham-do, Tye-kun-do, Der-ge, and Ta-chienlu in eastern Tibet. According to F. Spencer Chapman, "These swarthy, independent-looking people come down (to Lhasa) from Amdo, Golok, the high, desolate Chang Tang, and the far Mongolian border. Many of them bring herds of yak and sheep with them, carrying loads of wool, salt (which they collect from the shores of the great brackish lakes), and yak dung." They may also bring hides, yak tails, butter (packed in animal gut), borax, musk, and the horns of a certain deer. They make their pilgrimages about the city, pay their respects at the shrine of the last Lama, and perhaps perform more arduous devotions; buy a year's supply of barley, wheat, tea, peas, woolen cloth, a few turnips and radishes; and enjoy the blandishments of urban life for a time. Even the Golokpas, who are said to be professional brigands in their own district, periodically issue forth and go peaceably and unmolested to trade in other areas.

Trade of this seasonal and individual variety is conducted in small awning-covered stalls set up along the streets and open generally only in the morning. Transactions are said to be completed by hand signals, pressures, and so on, inside the long sleeves of the negotiators. The bargain is sealed with good wishes all around. Though there is a regular mercantile class of full-time specialists, every one engages in trade occasionally. The nobility have commercial agents who go to Peking, Mongolia, and India to buy them rare and valuable things; the large monasteries trade widely; and the government has many "purchasing agents" throughout Tibet and in foreign parts.

While trade between Tibet and the "outside" is, by western standards, on a small scale, it is essential to Tibet. Hides and wool are the chief exports, while in eastern Tibet clarified yak butter is sold in large quantities to the Chinese. Borax, yak tails, salt, musk, ponies and mules, medicinal herbs, and gold dust also pass beyond Tibetan borders. Imports from China are, primarily, tea (fourteen to fifteen million pounds a year being consumed) and, secondarily, silks, satins, brocades, cotton goods, dyes, matches, buttons, and rare foodstuffs. Imported from India are cotton goods, woolens, hardware, coral, precious stones, tobacco, Homburg hats, dried fruits, sugar, molasses, and miscellaneous domestic utilities such as matches, needles, and soap. From Nepal and Bhutan comes rice. Two caravans a year pass between Lhasa and Mongolia, carrying out woolen cloth, incense, and Tibetan scriptures,

* Continued from page 356.

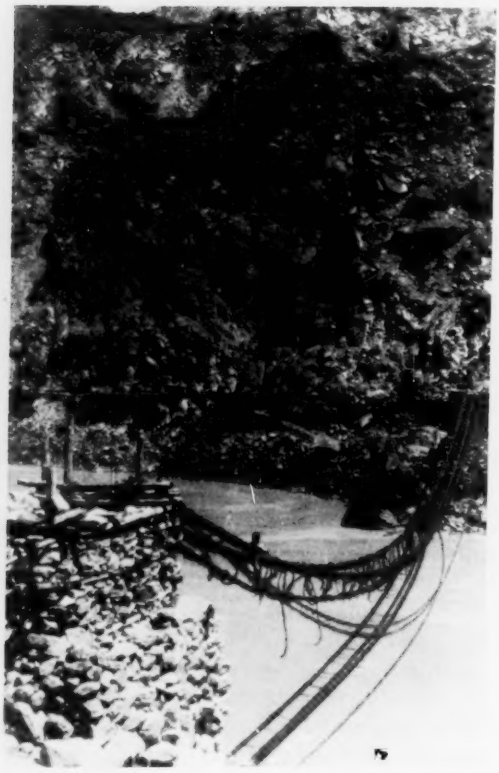


FIG. 11. WICKERWORK BRIDGE*
SUSPENDED ACROSS A GORGE IN WESTERN TIBET.

and bringing back Chinese silver, some gold, silk, and ponies. Tibetans are said to excel as caravan men, being able to pack expertly and to make long marches through inclement weather. Sino-Tibetan trade tends to pass more and more by water, Tibetan products often being floated down the Brahmaputra and other rivers (Fig. 11) to trade centers.

A part of Tibetan trade, both domestic and foreign, is in terms of cash, but payment in labor or commodities is still the rule, particularly within the domestic economic system. A landed proprietor will employ shepherds to look after flocks, which may amount to 20,000 sheep, under an arrangement that one lamb must be yearly added to the flock for every three sheep. Any deficiency must be made up, and any excess becomes the worker's profit. In addition, the owner supplies a small salary and salt for the sheep. Under another form of tenure the owner may specify amounts of yak butter, yak hair, and cheese to be produced per year, the excess being retained by the tenant. A proprietor may "let" the whole of an estate, the "lessor" taking subtenants who may pay him a fixed yearly sum in cash or grain, or who share equally with him the rent and the profits. The shepherd usually does not render unpaid services unless he combines farming with herding. Government revenues are paid in commodities or cash, usually in the former. Taxes are fairly heavy, and the government may requisition supplies (as animals and porters for officials and others on government business) and levy extra taxes in case of war or other emergency. Furthermore, noble families must supply two members for government work on nominal salaries or pay for a substitute. The taxes of a great family amount to nearly half its income. In case of need, however, mortgages on land and loans of cash or commodities, providing by contract the terms of repayment and interest, are made by the government, by individuals, or by the large monasteries.

While the tenant system implies frequent indebtedness and powerful ties of dependence upon the landlord, slavery is theoretically absent from Tibet and the employer-employee relation holds. In the Chumbi valley, where great prosperity has resulted from the passage of about half of the Tibeto-Indian trade, the natives employ servants from the interior to drive mule caravans and to perform household tasks. Wages paid are about twice as high as elsewhere. Landed proprietors maintain large servant staffs occupied not only in agriculture and grazing but also in spinning and weaving, in personal service, household tasks, and so on. Household servants are said to receive no wages. Where the "lord" commercializes fairly intensively on a given product, the "factory" may be a separate establishment on the estate in which live both male and female workers. They may devote all their daylight hours to their task, in return for which they receive board and lodging and a salary of one or two cents a day. On the large estates head farmers and herdsmen collect dues from their fellows and see that the landlord is supplied

* All photographs not otherwise credited are reproduced through the courtesy of the Peabody Museum, Harvard University.

with riding and transport animals when needed.

Tenants and servants thus stand in a position of heavy dependence upon the landed gentry. Social and economic dominance are exercised by the priestly and the noble classes, to whom the subordinated look for the services traditionally associated with their status. Nobles share with priests the higher administrative posts. The former inherit their prerogatives and, while wealth is generally concomitant, it is not necessarily so. Nobles are strictly defined as descendants of (1) an ancestor ennobled for a special service to the country, (2) a family in which a Dalai Lama or a Tashi Lama has taken rebirth, or (3) one of the early monarchs. Special titles are occasionally awarded for special services. Sons of landed gentry and nobles usually enter government service, but important lay officials are generally selected from a few ancient and noble families. Only in the monasteries do all men stand a fairly equal chance of achieving marked elevation of social status.

The Supreme Council of Tibet, composed of one priest and three or four laymen, exercises the highest governmental powers under the Dalai Lama or his Regent. There are, below this group, six grades of public officials. The government maintains two lists of officials, one lay and one ecclesiastic, each of about one hundred and seventy-five names. To enter the secular side a boy must first be apprenticed in the Finance Office where he receives training in accounting and the social intricacies of official correspondence. At about twenty he may receive his first public appointment, probably to become a Dzongpön of some little town which he never sees but governs through a deputy. As such, he is responsible for a district, supervising the collection of its revenues and the maintenance of order. After two or three years he may become a judge, deciding both civil and criminal cases and residing in one of the large towns. Subsequent promotions may ensue, the eventual office reached being dependent upon the usual multiple factors, purchase of power being not unknown. Nobles may exercise regulatory powers and inflict punishments upon their tenants and dependents within a rather wide range and in proportion to their distance from Lhasa, though in theory government permission must be granted before drastic action is taken. The aristocracy is scattered over the country, but its greatest concentration and power are found in central Tibet.

The priests act as a check upon the power of the nobles, and many of them are capable and strong-willed self-made men. If a boy is physically weak, if he gives evidence of unusual spiritual powers, or if the family is large and eager for the potential spiritual and material advantage to be gained, a youngster of three or four may be designated for the priesthood. Certain ceremonies mark this decision, after which the child may, if unusual, begin his studies immediately. He will usually remain at home until the age of six or eight. Having studied hard, learning to read and write, and memorizing vast masses of scripture, he may become a "clerical apprentice" by the age of sixteen, and an under-priest at twenty. Having successfully passed an examination, he will reach full priesthood and his functions thereafter will depend upon his special abilities and interests, the sect to which he belongs, and so on. Sects are many; there are perhaps twenty sub-orders and orders, of which about four are truly powerful. Tibetan Buddhism is descended from a much modified form of the faith, namely, Tantrik Buddhism, which reached Tibet from northern India in the eighth century A.D. and led to the "red-hat" orders of the priesthood. The "yellow-hat" orders were a reform group of later establishment and the sub-orders of still later origin. The spirit of the founder of the yellow-hat orders was held to have passed into a child born at about the moment of his death, and the modern Dalai Lama succession was so begun. The title, meaning "The All-embracing Lama, the Holder of the Thunderbolt," was given by the Altan Khan to the third of the line. The title of Dalai Lama is held in turn by each head of the yellow order.

The Dalai Lama exercises greater power and influence than any one else in the country, for he is regarded as the Buddha's Vice-Regent on earth. His position in the regard of the people is, therefore, assured and to him is accorded not only great control over

Courtesy of Mrs. C. Suydam Cutting

FIG. 12. INAUGURATING TANCHU, 1940

AT SIX THIS SON OF KUKU NOR SHEPHERDS WAS HAILED AS THE FOURTEENTH REINCARNATION OF THE BUDDHA.

material affairs but the reverence due his exalted incarnation. His spiritual power is nearly equaled, however, by that of the second official in the yellow-hat hierarchy. Dogmatic differences and keen rivalries between the sects and orders exist, but they are based more upon temporal than spiritual factors, and all recognize the two dignitaries above mentioned as the loftiest incarnations of the divinity (Fig. 12).

All the monasteries of the Gelugpa (the order of yellow lamas, as opposed to *all* others, which are regarded as red) are administered by the Dalai Lama through an appointed leader in each district, under whom an appointed "abbot" directs each monastic establishment. This hierarchy holds in general for all the other orders as well, each of which has a head comparable, in intra-order affairs, to the Dalai Lama. Under the abbot, in each monastery, are two classes of dignitaries, the one having charge of its temporal and the other of its spiritual administration. Such monasteries will accept for apprenticeship only superior children of good families. They are well fed and clothed and, by Tibetan standards, highly educated. Thus in the ecclesiastic body there tend to inhere the advantages of efficient organization, discipline, quality, and, lastly, the weight of numbers. Grenard estimates 500,000 for the country.

There are approximately 3,000 monasteries throughout the country, and each is advantageously situated for defense and is well armed (Figs. 13–15). Around them are great tracts for agriculture and pasturage, worked by tenants who produce for their ecclesiastical masters not only foodstuffs but also processed articles such as woolen goods, jewelry, and pottery. They are masons, carpenters, smiths, millers, and caravaneers, and are essentially subject to the monastic jurisdiction. The convents also hold accumulated treasures in gold, silver, and precious objects and receive innumerable beneficences, great and small. A bequest to the nearest convent comes from the inheritance of the deceased, the candidate for priesthood brings a dower, and every lama gives the convent part of his personal gains. F. Grenard, in *Tibet and the Tibetans*, remarks:

> For the lama is anything but a worthless asset. He is . . . a parish priest, a fortune-teller, a wizard, a doctor, an apothecary, a painter, a sculptor, a printer, a writer, a reader, a trader or a beggar; he sells little statues, prayer-wheels, books, lucky trinkets, rosaries, indulgences in pills, prayers, formulas, charms and amulets against all possible and impossible misfortunes, remedies, incantations and horoscopes. When a man marries or dies, the lamas come in the greatest possible number to assist him, for cash; when he meets with misfortune, they charge for driving away his bad luck; when he meets with good fortune, they charge for offering up thanks; when nothing happens to him, good or bad, they charge again for preventing things from becoming worse!

And not only for the individual and the family do they perform such functions, but also for the community and the state itself. But not all monks are practitioners. Some take vows of seclusion and may incarcerate themselves for years from the sight of man. Nor are all, as is the rule of the majority, celibate. Great diversity and range exist in the priestly mode of behavior, and the layman, while very fond of criticizing irregular behavior of the monks, is nonetheless respectful of the power they hold.

The complexity and diversity of Tibetan religious belief and practice are overwhelming in scope. One can do no more than attempt to identify within the maze certain

FIG. 13. THE MONASTERY OF LABRANG NEAR TIBET'S NORTHEAST BORDER

familiar avenues of religious expression. At least, it is quite apparent that Tibetan Buddhism is a travesty on Buddhism as originally taught. It preserves the conceptions of Karma and Nirvana, but the fine flights of abstract philosophy which characterized the original dogma are lost. From an abstract and nonpractical (in the material sense) philosophy and a nontheistic religion, Buddhism has become in Tibet a sort of monotheism with an enormous subsidiary pantheon of deified "saints," living incarnations, demons, personal guardians, ghosts, and so on, all of whom can be induced to leave an individual alone or to assist him if he knows the proper mode of approach, conciliation, or appeasement.

In all this there is ample evidence of mere elaboration of primitive Shamanism, the guardian-spirit belief, local "owners" and spirit placings, the association of the name with the soul, and even intermittent ancestor worship. There are indications of the abortive survival of animal sacrifice, the worship of household gods (in particular that of the hearth in association with the family and its continuity), the worship of gods of special function and those of local residence; even the celestial bodies play a part in this accumulation. "Mother Earth" is not omitted; the gods of sky and air, of the elements and of the elemental forces, all are remembered.

With all the multiplication of social, religious, and economic units, classes, and functions, the paternal family remains the basic common unit through which is inherited, to a large degree, status and role, prerogative and occupation, and property both corporeal and incorporeal. Personal genealogy is carefully preserved, and in theory all those united in blood recognize mutual responsibilities of assistance in times of crisis, even to the extent of exacting the price of the blood of a murdered kinsman.

The conjugal pair is usually brought together by the familiar intercessor, after much negotiating between the respective families under traditional conditions of gift exchange and ceremony. The bride is ceremonially brought to her father-in-law's house with etiquette sometimes suggestive of mock wife capture and with heavy emphasis upon the exchange of her old household gods for those of her husband's family. Actual wife capture is said to occur among the wilder nomads, while among the more sophisticated

FIG. 14. BUILDINGS OF LABRANG SHOWING ARCHITECTURAL EMBELLISHMENT

townsmen personal preference is given some consideration. Similarity of social and economic status and friendly relations between families appear to be the conditions basic to the arrangement of marriages. Elopement is not unknown, nor is it apparently severely punished. Among the very poor, the establishment of a common residence by mutual consent of the partners and their declaration, with or without witnesses, may constitute marriage.

Polygamy and monogamy are perhaps of almost equal frequency. The practice varies with local custom and the economic conditions of individuals. Among nomads monogamy is said to be of high frequency, coupled with the practice of dividing the patrimony between the sons. Among peasants this practice has practical disadvantages, fields and houses being less susceptible to subdivision than herds and pasturage. Hence, among peasants the frequency of polyandry may be regarded as a possible solution to the problem of keeping property intact, for levirate is the rule. The eldest brother in this case becomes the legal husband and father of the children, and upon his marriage he takes his father's place as head of the family. The younger brothers exercise equal conjugal rights, however, and act as "proxies" for the head of the house in carrying on its business. Should the eldest brother die before the majority of his eldest son, leadership passes to the second eldest. The position of younger brothers is that of owning, without having legal rights of administration over, the family property. All, however, are constrained to cooperate for the benefit of the family and the continuance of the line. If he desires, the head of the house may take a second and third wife, an arrangement which offers advantages in supplying the younger brothers with wives. Where there is no male issue, the daughter's husband may carry on the family line and take its name.

There is said to be no legal divorce, and the marriage bond is apparently seriously regarded, but in all probability divorce by mutual consent is fairly easy. Barrenness, laziness, or flagrant adultery of the wife are

FIG. 15. A VIEW OF LABRANG, SHOWING THE GREAT WHITE STUPA

the chief causes of separation. The last, however, is regarded as serious principally because it threatens the purity of the family line. A close personal friend, an adopted brother, or a distinguished personage will be expected to lay claim to the favors of the lady of the house, since he and his host are regarded as sharing, temporarily at least, in the bond of brotherhood.

Tibetans are said to be moderately prolific, but families are never large, due to the very high rate of infant mortality. There is no female infanticide, children of both sexes being greatly desired. Their education may be completely informal; it may be conducted by a village scholar and his head pupil, or by a private tutor. In any case it is likely to be limited to the "three R's" plus perhaps, among the wealthy, a little biography, history, and law (that is, moral precepts). An educated man in Lhasa is one who can write perfectly the complicated Tibetan script. While nearly all Tibetans can read a little, few can write.

Social diversion in the form of games, drinking and smoking, singing and dancing, centers much about the family life. Tibetans are said to be much in the habit of singing at their work, whether singly or in groups. They employ a number of musical instruments: the Hindu guitar, the Jew's harp, the bamboo or bone flute, and the tambourine. Religious music further involves trumpets small and large, cymbals, conch shells, and drums of many sizes and varieties. Religious dances employ elaborate masks, headdresses, and costumes. In secular dances men and women may dance together, as may master and servant.

Death is regarded as the release of the soul to a series of adventures which may result in its eventual re-entrance upon the "Wheel of Life." Little by little babies forget their past incarnations, and usually by the time they have learned to talk all memory of the past lives of the soul is forgotten. In rare instances this may not be the case, and so an important incarnation may be identified.

Disposal of the body is by exposure, in water, by burial, or by cremation. The last is reserved for lamas and high officials; the second for the lowest of the social strata—those without family or means. The very highest lamas are embalmed.

Though domestic economy and self-sufficiency within the family prevail in the production of essentials, the occupational specialist is not unknown in Tibet. From the information available it is not always easy to determine whether specialization is full-time; in the majority of cases one would guess that it is not. However, government officials, both lay and ecclesiastic, may be regarded as full-time specialists, as may priests. The occupations of the latter cover a wide range, as has been indicated, but it appears that division of function in the maintenance of the monastery and within the field of religious practice is very high. Professional traders and shopkeepers form a small but important middle class of commercial specialists, while closely allied with them in function are the bankers. The Newars of Nepal are said to be frequently found in the latter role in Tibetan cities. Teachers may be full- or part-time specialists, as are the entertainers who tour the country. In the cities are also to be found Chinese who are professional barbers and great numbers of beggars who, while unproductive in general, have certainly a professional status. Certain ones among them have recognized duties, as the disposal of human and animal corpses, searching for thieves who have fled into the country, and, formerly, the guarding of convicts. They are the scavengers of the city, and their begging status is fully institutionalized and regulated.

Among handicraft and processing specialists are metallurgists, weavers, tailors, shoemakers, builders, potters, and millers. Peasant, herdsman, and caravaneer are specialists to the degree that they produce, within their own sphere of economic activity, a surplus for trade which is relied upon by another group that does not produce such commodity or commodities or does not produce them in quantity to meet its own needs. Hand power, animal power, and water power are utilized, and machine power has been introduced on a limited scale.

Division of labor by sex and by age shows no unique features. Women do, however, play a rather more than usually dominant role in all spheres of activity save religion. Sexual discrimination is there at its height, yet women may become nuns and, in some cases, may be admitted to the monasteries. A woman may assume an important incarnation, in which case she will be accorded great honor and privilege, yet she can never reach the heights of secular power open to the priesthood. Women may manage shops and engage in retail trade generally. To country women fall not only the usual household duties and the care of the young and the infirm, but also carrying burdens, sowing and weeding, gathering fuel, milking, weaving, and the making of butter and cheese. Herding and ploughing are man's work, while irrigating, reaping, threshing, and winnowing are activities in which both sexes engage.

Tibet may be said to stand pre-eminently as an example of the achievement of cultural complexity in the face of environmental adversity. Many of the resources of the country are already being exploited, but when European influence adds techniques and breaks down dogmatic barriers a new avenue of exploitation—that of mineral resources—may be opened. Until that time Tibet may be expected to show little change; to remain a rather anomalous land of feudalism allied with theocracy, of herdsman complementing peasant.

GEOPHYSICAL MEASUREMENTS IN THE AMERICAN REPUBLICS

By L. O. COLBERT

MANY of the results of the Good Neighbor policy, intended to produce better relations with our sister republics, will have to rely for future value on the impressions made on the minds of men. The cooperative work of the Coast and Geodetic Survey, arranged in these American republics by our Department of State, has resulted in the establishment of permanent monuments, marking the points where precise measurements were made, which will be used for reference in future geophysical observations.

These cooperative measurements have included: gravity determinations in Colombia and Peru; the establishment and maintenance of fourteen automatic tide gages in eight countries; magnetic observations in all twenty of the American republics; cooperation in seismological work; arrangements for the exchange of personnel to assure standardized methods of observations; and translation into Spanish of several manuals on these geophysical operations.

Tidal measurements. One very successful program was the establishment of standard tide stations for the continuous operation of automatic tide gages in eight different countries from Mexico to Chile. An example of the difficulties of the tidal expert is given by the conditions at Panama and the Strait of Magellan. In Panama on the Atlantic side, the range is only one foot, but on the Pacific side the tide ranges from a mean of twelve feet to an extreme of sixteen feet. At the Strait of Magellan the range on the Pacific side is only four feet. On the Atlantic side the average range is thirty feet with a maximum of thirty-nine, one of the greatest of the earth.

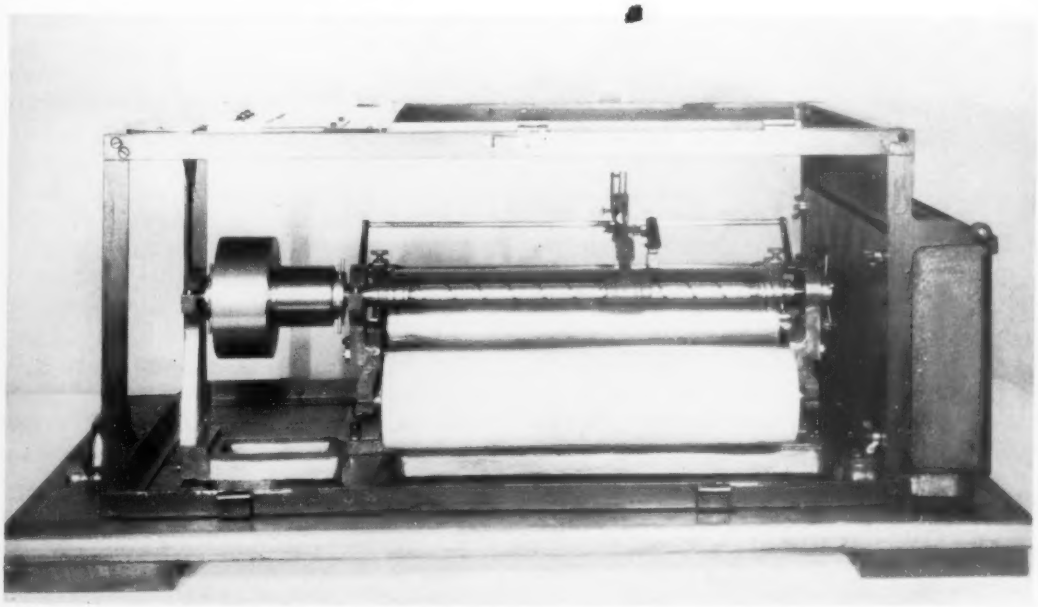


FIG. 1. STANDARD TIDE GAGE, U. S. COAST AND GEODETIC SURVEY

Tide predictions have become commonplace. The average user of the tide tables does not know that back of them is the tide-predicting machine, and behind this not less than one year of continuous tide observations at several ports, followed by mathematical analysis of the results. The Coast and Geodetic Survey has for many years predicted tides for all parts of the earth, but has been handicapped in those portions where observations have been meager.

Because few observations had been made in many parts of the Americas, a number of the American republics welcomed a plan, initiated in 1941, whereby the Coast and Geodetic Survey furnished and installed automatic tide gages at principal seaports and inspected them annually. Each country concerned maintains them in operation and collects the records for analysis. The fourteen stations are distributed as follows: three in Mexico; two in Central America; nine in South America, one of which is in the Strait of Magellan. As a result, the tide tables are now providing daily prediction for the more important ports, especially on the Pacific Coast of South America, and improved tidal data for the whole of that coast.

A tidal station includes an automatic gage, a tide staff, and a number of benchmarks. The automatic gage consists of a recorder (Fig. 1) connected by a flexible wire to a partly submerged copper float. The wire is wound around the pulley on the left of the recorder so that by a suitable mechanism a pencil records the rise and fall of the float with the tide. The recording mechanism is moved along the surface of the clock-driven drum at a uniform rate, so that the record gives a continuous curve from which the height of the tide at any instant may be obtained. The tide staff is simply a board with painted graduations, so placed that it extends above and below the greatest range of the tide. At daily intervals the record on the gage is compared with the readings of the tide staff. This gives the height of the tide with reference to the zero mark of the tide staff.

The next step is to carry a line of levels from the zero of the staff to not less than five reference points on shore, each marked by a bronze disk set in the top of a concrete pier. These marked points become individual bench marks of known elevation when continuous observations of the rise and fall of the tide have been analyzed and the various tidal datum planes determined.

Knowledge of the tide is necessary in daily coastal navigation, in connection with waterfront industrial construction, and in harbor improvements. For these uses the maximum, as well as minimum, tidal ranges are needed.

The tidal plane of mean sea level, to which all elevations on land are referred, may be defined as the mean or average height of tide at the point of observation, as derived by analysis of the tide record. It is difficult to arrive at a common plane of mean sea level, as varying meteorological conditions affect the observations at different stations. There may also be slow or rapid changes in elevation, usually associated with major earthquakes, which are especially likely to occur on the shores of the Pacific Ocean. The geologist is interested in these from the viewpoint of world-wide changes of mean sea level, especially to learn whether it is the land or sea whose elevation is changing. For these purposes observations over a considerable period of time are required. It is hoped that most of the tidal stations now established on the Pacific Coast from Alaska to Chile will be continued in operation for a number of years.

It is desirable, when possible, to connect all tide stations with precise level lines to determine the difference between the mean sea levels at different coastal points. At the Isthmus of Panama where this has been done, mean sea level was found to be three-quarters of a foot higher on the Pacific side than on the Atlantic. A similar determination at the Strait of Magellan, which would be desirable, cannot yet be made because of lack of sufficient tidal observations at each end.

The west coast of South America suffers from time to time from great seismic sea waves, which sometimes reach the height of eighty feet, causing damage to shipping and to coastal structures. These can now be recorded at those tide gages which are of sufficient distance from the origin for the wave to be within the recording range of the

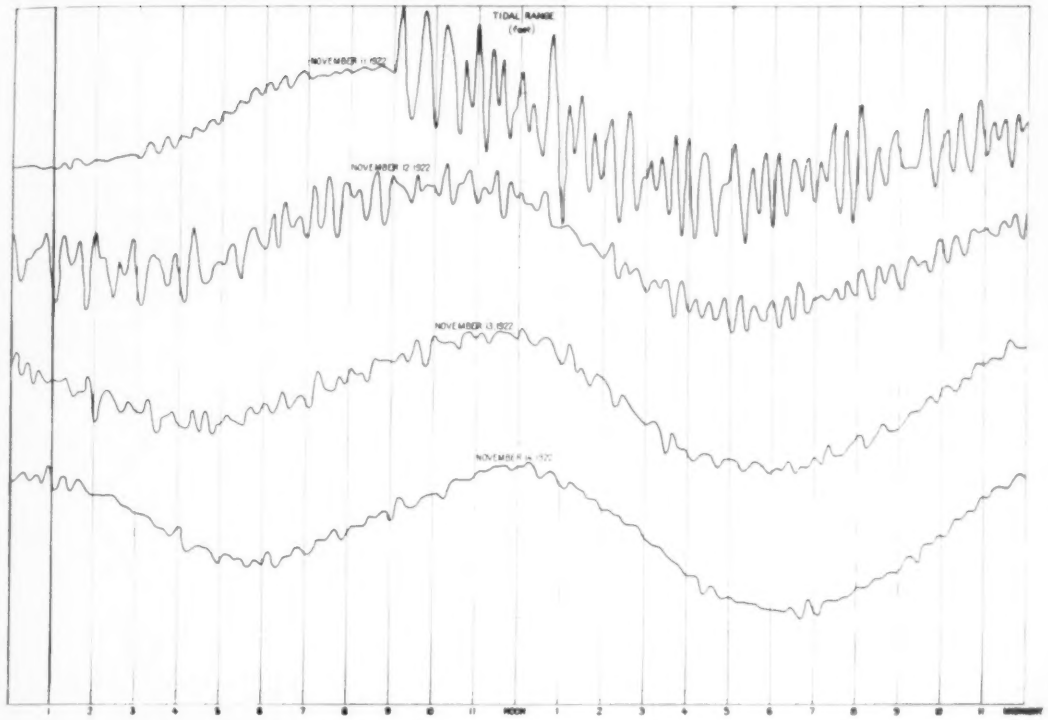


FIG. 2. DESTRUCTIVE TIDAL WAVE IN CHILE RECORDED AT HONOLULU

gage (Fig. 2). No means has yet been found for recording great destructive waves near their place of origin.

Geomagnetism. The situation regarding magnetic observation in the Americas has been quite different from that of tidal observations. The Department of Terrestrial Magnetism of the Carnegie Institution of Washington, in order to have needed data for its world-wide studies, inaugurated in 1905 a program of magnetic surveys in all countries which did not have organized surveys of their own. Mexico and Argentina were originally included in this program but soon established, and have since maintained, their own magnetic surveys, including the operation of magnetic observatories.

The continuous records from observatories, in addition to serving other useful purposes, furnish the necessary corrections to field observations. Of the observatories used for this purpose, Mexico and Brazil each have one, Argentina three, Peru one (operated by the Carnegie Institution) and Puerto Rico one (Coast and Geodetic Survey). These, however, are too few to indicate the changes in the earth's magnetic field; consequently the Carnegie Institution made repeat observations at selected places at approximately ten-year intervals.

The plan worked satisfactorily through 1932, after which a break in continuity threatened. This was especially serious because of the peculiar magnetic conditions in the area. To understand these a review of the basic facts regarding the earth's magnetism is desirable.

Since a magnetic field is in three dimensions and is difficult to deal with as a whole, it is separated into components usually referred to as magnetic elements. The planes of reference for any point of observation include the true meridian, the magnetic meridian (the vertical plane of the direction taken by a freely suspended magnet), and the plane of the horizon. The elements include: declination, D, the angle between the true and magnetic meridians; inclination or dip, I; and total intensity, F, more usually

broken down into horizontal intensity, H, and vertical intensity, Z. The various instruments which serve to measure or to utilize the earth's field usually relate to only one, or at most two, of these elements.

Declination and vertical intensity are in most common use. Anyone who has a magnetic compass can obtain a true direction if he knows the declination at the point of observation. Vertical intensity is used in geophysical exploration for oil and minerals.

The distribution of the field is far from symmetrical, and there are many places where there are marked local departures from uniformity. These are known as magnetic anomalies. They are usually due to the presence of magnetic iron or other ferromagnetic materials associated with igneous rocks and sediments derived from them.

A convenient method of studying magnetic changes with time, or the secular change, is the drawing for a selected period of isopors or lines of equal change of a selected element. In some places the rates of change are large and the isopors form a series of closed curves resembling the isobars of a meteorological depression. These are known as isoporic foci.

South America is a region of interesting and unusual magnetic conditions, some of which have an effect far to the north. The magnetic equator, which crosses South America about ten degrees south of the true equator, has been slowly moving southward; and it is important to know whether this trend is continuing, especially as it may be related to movement of the magnetic poles. While daily variation of the magnetic elements is a universal phenomenon, that of horizontal intensity in most of South America is very large, and a daily lunar effect, which elsewhere can be detected only by statistical methods, can be readily separated.

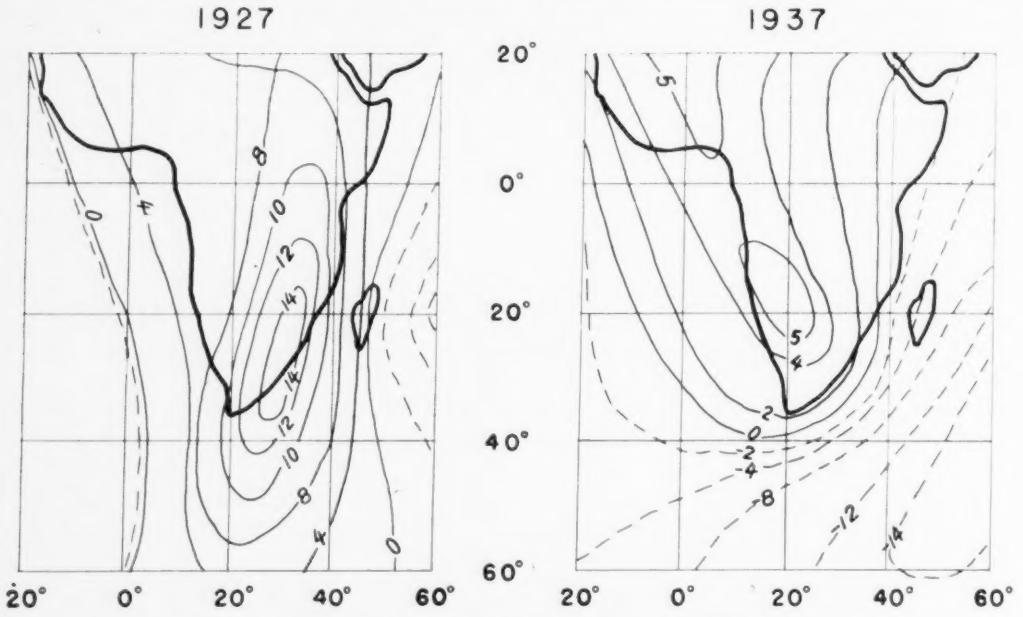


FIG. 3. CHANGES OF ISOPORIC FOCI OF DECLINATION

In the recent past there were marked isoporic foci in all the elements in different parts of South America; these foci are subject to change both in position and maximum amount, to disappearance, and to the development of new ones (Fig. 3). The isopors in declination in the United States have been changing in an unusual manner and this may reflect changes to the south. These changes can become known only through continued or repeated observations.

The Coast and Geodetic Survey had demonstrated in its work in Alaska that the field

observing equipment ordinarily weighing 600 lbs. could be reduced to 150 lbs. and thus make transportation by airplane practicable. Silk was substituted for canvas for the observing tent used to protect the instruments from the wind and sun. Three heavy, bulky, padded carrying boxes were reduced to one light, compact case (Fig. 4). To obtain the necessary correct time the airplane or airport radio was used instead of a special radio and battery.

Due to the rapid expansion of airlines in South America, most of the magnetic stations that had to be recovered and reoccupied could be reached by airplane. A cooperative program, therefore, was set up with all the American republics in which the Coast and Geodetic Survey would make the repeat survey which was due after ten years. Observations were made at from one to twenty locations in each of the republics. The two geophysicists were accompanied by one or more scientists of the particular country. In the republics that maintain their own magnetic surveys and operate observatories, the work was confined chiefly to comparison of the Coast and Geodetic Survey field instruments at the observatories.

The observations were made in a tent to protect the instruments from the sun and wind (Fig. 5). The tent fixtures must be nonmagnetic. In fact there also must be no magnetic material on the observer. This applies to all items—eyeglass frames, metal buttons, buckles.

Observations at a field magnetic station usually required two days. The first day's program consisted of testing the station for local magnetic disturbances, making solar observations for latitude, longitude, and true azimuths, and of making a series of magnetic observations including magnetic declination, the horizontal intensity of the earth's magnetic field, and the dip or inclination of the lines of force. The second day was used for repeating the magnetic observations and marking the station.

Magnetic declination was measured by observing the angle between the true north and the direction indicated by a magnet free to swing in a horizontal plane about a vertical axis. The measurement of the earth's horizontal field consisted of a combination of (1) oscillations, which serve to determine the product of the magnetic moment of the oscillating magnet and the horizontal intensity and (2) deflections, from which the ratio of the same two quantities is obtained. Dip, or inclination of the lines of force of the earth's magnetic field, was measured by means of an earth inductor, which is practically a small generator. Its operation is based on the fact that when a closed coil of wire is rotated in a magnetic field an electric current is generated in the coil except when the axis of rotation is parallel to the lines of force of the field. A small astatic galvanometer is used to determine whether or not an electric current is being generated by the earth inductor. The position of the coil is moved until the galvanometer reads zero.

FIG. 4. MAGNETIC INSTRUMENTS
FOR AIRPLANE TRANSPORTATION TO FIELD STATIONS.

As yet, no satisfactory field instrument has been devised to measure directly the absolute value of vertical intensity of the earth's magnetic field. This component must be computed from the horizontal intensity and the dip; that is, H tan I.

The instruments in the magnetic observatories record the magnetic elements continuously. Thus all variations and fluctuations such as magnetic storms are recorded. Through exchange, the records are studied by scientists of many countries.

The magnetic survey, as far as it has gone,

FIG. 5. MAGNETIC OBSERVER IN TENT, SANTA ELENA, VENEZUELA

is up-to-date and the distribution of stations has been improved. The chief need now is for many more observations to map magnetic anomalies.

The earth's magnetism has the unique distinction of being in constant use and yet remaining an unsolved mystery. Its everyday use is in obtaining direction, especially when other methods fail, and in relation to radio communication. Its mystery lies in the failure of all the resources of physics to explain why the earth has a magnetic field and why this field shifts at a variable, unpredictable rate. Continuity of observation, especially of unusual conditions, is an obvious requisite to eventual solution of the mystery.

Magnetic observations in the vicinity of a new volcano. A quite unusual and in some respects unique program of magnetic work was carried out in 1943. In February a new volcano, named Paricutin from a village which it destroyed, started its eruption in a cultivated field about 200 miles west of Mexico City. There was no previously known outbreak in the region in historic time, though there was ample evidence of prehistoric activity. The only known similar eruptions of new volcanoes in cultivated land were those of Jorullo, Mexico, in 1759, and of Izalco, El Salvador, in 1770.

Magnetic observations have been made in the region surrounding Santa Maria volcano in Guatemala by the Carnegie Institution of

Washington and the Pan-American Institute of Geography and History, and in the vicinity of several Japanese volcanoes—the most recent being that on Miyake Island in the island group extending southward from central Japan. The reason for such observations is that when the underlying magma becomes fluid, its temperature is well above that at which it loses its magnetism (in the case of magnetite about 750° C.). Accordingly, a magnetic survey may disclose the condition of the underlying magma and may even be a guide to the volcanic activity. As the magma cools, it regains magnetism through induction in the earth's field. The problem is usually complicated by masses of unheated magnetic material.

Under these most unusual circumstances the Coast and Geodetic Survey, with the cooperation of the Mexican Government, made a magnetic survey, chiefly of vertical intensity, in the region surrounding the Paricutin volcano (Figs. 6 and 7). The survey started about three months after the first eruption, and during its progress the volcano was actively building up its cone and extending its lava field. It is too early to appraise the results of the survey except that it appears that there are much smaller magnetic anomalies than for the other volcanoes investigated. This may help to account for the observed wide variation in the degree of magnetization of long inactive volcanic material.

FIG. 6. PARICUTIN VOLCANO
SHOWING LAVA FOUR MONTHS AFTER FIRST ERUPTION.

FIG. 7. MAGNETIC OBSERVATIONS
NEAR ERUPTING PARICUTIN VOLCANO, MEXICO, 1943.

Gravity measurements. The first project of the Inter-American cooperation with the Coast and Geodetic Survey was one for the determination of the force of gravity by the use of pendulum gravity apparatus at a number of base stations in Colombia and Peru. Values of the force of gravity of proper distribution over the surface of the earth form an excellent means of determining the shape of the earth. It is well known that while gravity is constant at any point (neglecting geologic changes) it varies from place to place according to latitude, elevation, or the hidden structure below the surface. Quite frequently the differences between the theoretical and actual gravity values (anomalies) from place to place are relatively large after corrections have been applied for latitude and elevation. Such differences are presumed to be caused by absence of isostatic compensation or by buried structures of varied density, includ-

FIG. 8. GRAVITY ANOMALIES ALONG UPPER WESTERN COAST OF SOUTH AMERICA

ing salt domes and other structures associated with petroleum. Accordingly, gravity surveys have been used, for some two decades, alone or along with seismic or other methods, in the search for new oil deposits. The type of instrument now in general use is the gravimeter, which furnishes surprisingly accurate results over restricted areas when the instrument can be frequently tested at pendulum gravity stations.

Because the gravity anomaly may also represent lack of isostatic compensation, importance is attached to the collection of such data in regions known to be subject to intense earthquake activity, such as the western slope of the Andean Cordillera. Already large gravity anomalies have been found through the observations in Colombia and Peru (Fig. 8). The few base stations determined by these recent measurements provide reference points for whatever additional work may be done in the future in those countries for any of the purposes mentioned. Additional observations in these and other countries in South America, particularly those bordering the Pacific coast, would be most enlightening to geophysicists who are studying these matters. Much interest has been taken in the work of the Bureau so far accomplished and in the possible resumption of the work which was suspended because of the war.

The successful accomplishment of these geophysical measurements by the Coast and Geodetic Survey was possible only through effective cooperation of the government in each of the American republics. Furthermore, it is well recognized that there is special need for coordination and maintenance of standards among all the countries on this hemisphere in other scientific work such as triangulation, precise leveling, astronomic observations, and seismology. Many of the countries have been carrying on excellent work in these subjects.

There has been nothing one-sided about the benefits received through cooperative effort. The results will be utilized for the mutual advantage of all through a better knowledge of these geophysical features which affect all countries to a greater or less degree.

REAR ADMIRAL LEO OTIS COLBERT

ADMIRAL COLBERT, C.E., Sc.D., is Director of the U. S. Coast and Geodetic Survey, Department of Commerce, Washington, D. C. He was born in Cambridge, Massachusetts, in 1883 and was graduated from Tufts College in 1907 as a civil engineer. He then entered the Coast and Geodetic Survey to which he has devoted his entire professional career. In 1938 he became its Director and in 1939 his Alma Mater recognized his achievements by bestowing upon him the honorary degree of Doctor of Science. Admiral Colbert does not tell us how he became a sailor, but from the start we find him aboard ship; from 1907 to 1910 on wire-drag work on the Atlantic Coast and Alaska, and from 1911 to 1917 as executive officer and later as commanding officer of Survey vessels in the Philippines, on the Pacific Coast, and in Alaska. In September 1917, he was transferred by Executive Order to the Navy and served as Lieutenant and Lieutenant Commander on the U.S.S. Northern Pacific, a troop transport ship. After the war he spent nine years of shore duty in the Washington office of the Survey, followed by three years in Manila as Director of Coast Surveys of the Philippine Islands. Upon his return to the States in 1931 he became commanding officer of the Survey steamer Oceanographer, which was engaged in the use of acoustic methods for making soundings of Georges Bank off the coast of Maine. According to R. A. Daly in *The Floor of the Ocean* this survey resulted in "the first maps to illustrate well the association of canyon, furrow, and ridge. . . ." From 1933 until he became Director, Admiral Colbert was in charge of chart production and correction. His interest in maps also extends to aeronautical charts, for his daughter is a first-class WASP in the Air Transport Command of the Army Air Forces. He is a member of the Mississippi River Commission and trustee, director, or member of several organizations having a bearing on his work. In spite of his preoccupation with war duties Admiral Colbert has taken a great interest in promoting in the American Republics geophysical measurements which are of benefit to all but which are to be accomplished only through cooperation.

APPLIED GENETICS IN FORESTRY

By G. A. PEARSON

MAN-MADE forests may never attain the grandeur of nature's forests. The reason lies not so much in man's inability to fathom the secrets of nature as in his impatience to reap the reward of his efforts. Nature has taken anywhere from three hundred to five hundred or more years to grow the forest giants which command our admiration and reverence—white pine in the East, ponderosa pine in Arizona (Fig. 1), Douglas-fir in Oregon, or the redwoods in California. Within another half century these biological wonders will cease to exist except where small areas have been preserved for scientific or aesthetic reasons. While commercial forests may for many years continue to harbor remnants of the original stands, they will be made up largely of trees less than one hundred and fifty years old. At the present time the clear, even-grained boards which command almost prohibitive prices in lumber markets are sawed from towering veterans of unbelievable age. If we would continue to use this class of timber, we must devise means of growing it in less than half the time nature has taken.

Such, in brief, is the problem which confronts American foresters today. Some would evade the problem by doing without high-grade lumber. They would be content with the small, knotty, and defective boards which now supply much of the lumber trade in the East and South. Others would resort to fabricated material in which small pieces of clear wood are glued together into larger sections of desired form; or they would con-

FIG. 1. A MATURE STAND OF PONDEROSA PINE
IN THE FORT VALLEY EXPERIMENTAL FOREST, ARIZONA. THE TREES ARE ABOUT THREE HUNDRED YEARS OLD AND MANY ARE OVER THIRTY INCHES IN DIAMETER. THEY ARE IN GREAT DEMAND.

FIG. 2. AN OLD CUTTING OF PONDEROSA PINE UNDER PRIVATE CONTROL
LOGGERS LEFT TOO FEW SEED TREES FOR GOOD NATURAL REGENERATION. A NEW VARIETY OF PINE COULD BE INTRODUCED ON THIS LAND IF ONE WERE FOUND ADAPTABLE TO THE SITE.

vert knotty trees into pulp from which a great variety of synthetic wood products can be made. Some investigators believe that, by the introduction of new species from foreign countries or by the development of hybrids, it is possible to produce supertrees which will yield usable timber in a small fraction of the time now required. Still others would rely mainly on selection and cultural practices to bring native species to a high degree of productive efficieney.

In the effort to maintain an adequate supply of wood products in the face of dwindling natural supplies, no reasonable prospect should be overlooked. All the methods here listed deserve attention, but since the first three lie outside the sphere of this discussion, only the last two, involving improved methods of breeding and growing timber, will be discussed.

Plant breeding has revolutionized agriculture and, in somewhat different ways, it can do the same for forestry, which is really a form of agriculture. Tree genetics is being studied systematically at several of the forest experiment stations operated by the United States Forest Service; one of these, the California Forest and Range Experiment Station, has a division of genetics with a field station devoted entirely to the breeding of forest trees.

The thought of hybrid trees combining the desirable qualties of several species or strains appeals to the imagination. Already sufficient progress has been made to indicate astounding possibilities. But the vision of man-made miracle forests replacing extensive areas of natural woodland is not likely to be realized in the near future. To appreciate the obstacles to such a program it is sufficient to enumerate only a few of them.

The long period between germination and seed bearing in forest trees, as compared with most plants, increases manyfold the time required to develop and fix new varieties.

Once a hybrid has been developed in the laboratory and nursery, or a new species introduced from a foreign country, tests under field conditions must run through the greater part of a life cycle in order to determine how the newcomer will react to the many factors of a complex environment.

The introduction of new varieties presupposes artificial propagation, whereas natural regeneration is the framework of the present forestry structure.

On denuded lands requiring reforestation it is possible and practical to introduce new species, hybrids or selected strains after tests have proven them adapted to the conditions of the site (Fig. 2). Because of the tendency toward reversion and to cross-pollination

FIG. 3. PONDEROSA PINE IN THE DRIER PORTIONS OF ITS RANGE
MAINTAINS PURE STANDS BY REPRODUCING ITS OWN KIND EACH GENERATION. IN MORE HUMID SECTIONS, OTHER SPECIES SUCH AS FIRS WOULD TEND TO DOMINATE IN THE SECOND GENERATION.

with remnants of native stock, however, nature could not be relied upon to perpetuate the introduced varieties in succeeding generations. Instead of natural restocking when the crop is harvested, it might be necessary to plant with stock propagated from seed of known pedigree, or from cuttings. But, notwithstanding the difficulties involved, anyone would be rash to assert that this process may not some day become practicable. It seems safe to assume, however, that as long as extensive natural forests remain and prove capable of meeting the requirements placed upon them, they are not likely to be subjected to such drastic treatment as eradication and replacement.

Guiding Natural Selection

At present the greatest opportunity in forestry lies in the improvement of existing forests rather than in replacing them. Natural forests contain both good and poor types of trees, as measured by both biological and economic standards. The task of the forester is to repress the undesirable and favor the more desirable types.

There are few plant associations in which natural selection is carried on so consistently and so ruthlessly as in a forest. The survivors are certainly the fittest biologically if not economically. Propagation of the qualities which best serve mankind is man's own responsibility. Both heredity and environment figure in the development of the individual tree. Heredity determines potentialities; environment either fosters or inhibits these potentialities. The best of species or strains cannot make the most of their inherent potentialities without suitable physical conditions, nor can the optimum physical complex produce a high-class forest out of inferior species.

The characteristics most sought in forest trees are persistence, vigor, good form, and high quality of the wood.

Persistence. Natural forests are, generally speaking, a product of their environ-

ment, plus chance. If undisturbed by man they may be said to represent the producing capacity of what foresters call the site. Composition is determined by the capacity of species, and of strains within species, to tolerate adverse elements of the site and to take advantage of the favorable elements. The trees which maintain their position in the forest through generations must be able to compete with their neighbors for a place in the sun and the soil. They must be able in one way or another to resist or adjust themselves to the ravages of fire, disease, insect and rodent pests; and, finally, they must be capable of regeneration under the conditions encountered.

Ponderosa pine (*Pinus ponderosa*) in the interior and more arid portion of its range is an example of a tree in adjustment to its habitat. It has maintained practically pure stands over vast areas of western United States through generations, and promises to continue so indefinitely (Fig. 3). Douglas-fir (*Pseudotsuga taxifolia*), on the other hand, is a subclimax species, which is usually found in mixture with the true firs of the genus *Abies*. It often starts in pure stand following fires, but after the first generation it gives way to the true firs, which are better able to regenerate under cover.

Vigor. Each species has definite limitations as to growth capacity in a given environment; it is found also that within species there exists wide individual variation. Usually, however, the so-called fast-growing species grow rapidly only under conditions favorable to them, and they may fail entirely on poor sites where slow-growing species are able to persist. The popular dream of a

FIG. 4. GOOD AND POOR FORM IN SAW TIMBER

A, ILLUSTRATES THE LONG, CLEAN, COLUMNAR TRUNKS DESIRABLE FOR LUMBER; **B**, THE MUCH-BRANCHED AND FORKED TYPE THAT IS SPLENDID FOR SHADE BUT VALUELESS FOR LUMBER.

tree which will grow rapidly with little water is likely to remain only a dream. Rapid growth of individual trees does not necessarily signify efficient use of soil, water, and light; it may mean simply that the individual has been able to appropriate at the expense of its neighbors more than a fair share of the elements concerned in growth. It follows that for economic purposes productive capacity should be measured not only in the growth rate of individual trees but also in yield per acre.

Rapid growth is often attained at a sacrifice of quality. Coniferous trees usually produce the best wood, whether for lumber or for pulp, when growing at a slow, or moderate but uniform, rate. Markets for aircraft material and other specialized products commonly specify a maximum width of growth rings in the better grades of lumber. Broadleaf trees, on the other hand, may combine rapid growth with increased strength, toughness, and resilience. Thus, the famed second-growth hickory, much prized for axe handles, is a product of certain fast-growing young trees.

Form. Good form in trees is a relative term, the definition of which depends on the use contemplated. The broad crown and picturesque forking and branching so desirable in a shade tree are characteristics to be avoided in trees grown for lumber. Good form in a timber tree implies a straight, nearly cylindrical trunk, or bole, free of branches to at least half of its height. The opposite characteristics, namely, a short, limby, tapering bole, make for knotty lumber and waste in manufacture (Fig. 4).

The best timber form is attained when trees grow in close formation. Under these conditions competition forces the tree upward, figuratively reaching for sunlight, and encourages "natural pruning" in which the lower branches die and eventually fall to the ground, leaving what foresters call a clean

FIG. 5. PORCUPINE INJURY AND MISTLETOE INFECTION

A, THE FORKED BOLE RESULTED FROM AN ATTACK BY A PORCUPINE WHEN THE TREE WAS YOUNG.
B, A VALUELESS PINE WHOSE BRANCHES HAVE BEEN DISTORTED BY THE MISTLETOE PARASITE.

FIG. 6. MATURE PONDEROSA PINE AFTER THE FIRST CUTTING
THIS CUTTING WAS CAREFULLY DONE BY THE METHOD OF IMPROVEMENT SELECTION. LIGHT CUTTINGS AT TWENTY-YEAR INTERVALS WILL STIMULATE GROWTH IN THE REMAINING TREES.

bole. Open spacing encourages lateral branch growth and persistence of branches almost to the ground. Although species differ in degree of response to these influences, the relationships are universal. Even in fairly dense stands, however, some individuals develop the branchy habit and expand laterally at the expense of their neighbors. Extreme types of this class have for generations been called wolf trees.

Wolf trees may be a product of either heredity or environment. In many instances they are merely the most vigorous growers which, after outstripping their neighbors, have expanded without restraint. In other instances, coarse branching and forking show all indications of being hereditary. A majority of the cases of abnormal branching are traceable to some form of injury. The porcupine, by girdling the main stem of a young tree near the top, arrests height growth and stimulates branch growth. Repeated cutting of terminals by the Abert squirrel in Arizona may bring about similar effects. Mistletoe causes branches and even the main stem to assume grotesque forms which may render the tree valueless for lumber (Fig. 5). Snow is a common cause of crooked boles; the young tree is bent over by unequal distribution of the snow load, then when growth is resumed the new terminal shoot rises vertically while the old axis remains in an inclined position.

Quality. The wood of every tree has certain qualities which are characteristic of the species to which it belongs. White oak is noted for its strength, hardness, and beauty of figure; white pine for its softness, uniformity of texture, and ease with which it can be worked; red cedar for its rich color, its pleasing odor, and its resistance to decay. Whether a certain quality is desirable or essential depends on the purpose for which the wood is to be used. For instance, beauty of figure and hardness are desirable in a table top, but pattern-making calls for a soft wood free from the irregularities which make

FIG. 7. IMPROVEMENT OF A YOUNG PONDEROSA PINE STAND BY CUTTING
MOST OF THE MATURE TIMBER WAS LOGGED TWENTY YEARS AGO. THE LARGEST REMAINING TREES ARE TOO LIMBY TO MAKE GOOD LUMBER AND ARE DOMINATING BETTER SMALLER TREES.

the pronounced grain in oak and in some pines. Supporting timbers in a house should be strong; but strength is less essential in siding, which in turn calls for workability, paintability, and resistance to the deteriorating influences of weather.

Under present circumstances, the best opportunity for improving quality in woods lies in making the most of desirable characteristics in existing species rather than searching for miracle woods in new varieties or hybrids. In all trees certain characteristics are associated with age, size, and environment. For example, in the so-called durable species usually it is only the heartwood that is durable and heartwood is most fully developed in old trees of large size. Rate of growth and variation in growth rate influence texture, strength, and seasoning qualities. Leaning trees often have an objectionable structural distortion known as compression wood. Clear lumber of any species comes from trees that shed their lower branches early in life; the knotty pine, now gaining favor for interior finish, is obtained from sections of the trunk which have retained live branches, forming a tight knot, as distinguished from the loose knot formed when growth layers are deposited around persistent dead branches.

Genetics Applied in Commercial Cutting

Strange as it may seem to the layman, logging affords one of the most effective means of improving commercial timber stands. A cutting practice designed especially to favor the best trees in stands of ponderosa pine has been applied in the Fort Valley Experimental Forest in Arizona, under the name, "improvement selection." Trees of undesirable type are marked for cutting while those of the best type are left for growth and regeneration. This selective logging is repeated at intervals of ten to twenty years, always favoring the best elements of the stand by removing the poorest (Figs. 6, 7, 8).

Improvement selection does not overlook immediate economic and industrial aspects. A lumberman compelled to handle only in-

ferior logs would not be able to compete in the lumber market. Trees of such low quality that the sale value of their product will not equal the cost of transporting the logs to the mill and sawing them into lumber or converting them into other useful products are disposed of in the cheapest manner possible, usually by poisoning with a sodium arsenite solution, at a cost of a few cents per tree, or by girdling. Timber management aims to grow a class of product that will return a profit to grower and manufacturer, and at the same time provide maximum utility for the consumer.

In practice, selective cutting designed to improve a forest will proceed along the following lines:

Large, merchantable, mature trees of all classes are cut except as occasional individuals may be needed for regeneration. Merchantable, immature trees are cut if diseased, injured, or of poor form.

Unmerchantable trees whose presence is regarded as harmful to the stand are eliminated at minimum cost by poisoning or by girdling. Especially included are the wolf trees dominating smaller trees of good form and mistletoe-infected or otherwise diseased trees which may infect the younger generation.

Immature trees of good form are left unless they are too close together for satisfactory growth, when the surplus trees are removed in order to improve spacing.

Removal of mature trees is in conformance with the biological law that maturity is followed by decline and that a mature crop of any kind must be harvested if loss and waste are to be avoided. In forest trees, however, maturity is a relative term. Trees which have attained biological maturity may go on growing for hundreds of years if their roots and crowns have room enough to function normally. It is therefore good practice in some species, such as ponderosa pine, to harvest dense, mature stands in a series of cuttings, taking first the largest stems and those which show signs of decline and leav-

FIG. 8. YOUNG PONDEROSA PINE SHOWN IN FIG. 7 AFTER A SECOND CUTTING
TWO OF THE LARGER TREES HAVE BEEN REMOVED, LIBERATING THEIR SMALLER NEIGHBORS WHICH WILL NOW GROW MORE RAPIDLY; THEY ARE BEING PRUNED TO INDUCE CLEAN BOLES.

FIG. 9. A DOUBLE WOLF TREE
KILLED BY POISONING. IT IS WORTHLESS FOR LUMBER, AND IF FELLED WOULD DESTROY MANY SMALL TREES. THIS TREE, BY ITS SHADE AND ROOT ACTIVITY, HAS SUPPRESSED YOUNG TREES WITHIN A SPACE OF FIFTY FEET.

ing others for further growth. Trees of poor form are removed in early cuttings because they occupy space which can be utilized to better advantage by those of normal form. Whether abnormal trees will beget progeny of the same type cannot always be said with certainty. Nevertheless, removal of abnormal types is a precaution in favor of future generations.

Isolated wolf trees and others whose form renders them worthless for lumber can in the younger stages be made to serve a useful purpose temporarily as "nurse" trees. If the crown is not too low, seedlings start underneath its periphery and, under the influence of partial shade, grow into tall, slender, almost branchless poles. Unrestrained, the wolf tree reaches out and strangles these ambitious youngsters, but if the wolf tree dies or declines, they grow into trees of the finest type. Sometimes lightning performs the needed service; man can do it by felling or poisoning the abnormal tree. Poisoning is accomplished by introducing sodium arsenite solution into holes bored in the trunk. Sudden removal by felling exposes the slender poles to snow damage; poisoning leaves the dead tree standing, its massive branches shielding the young poles until they become strong enough to withstand the snow load (Fig. 9).

Mistletoe-infected trees are cut because they are a menace to their neighbors and because sooner or later they themselves will succumb to the parasite. It is common observation, however, that in groups of young trees which have been equally exposed some have escaped infection while others have not. Many foresters believe, and with good logic, that certain strains of a species are resistant to mistletoe. Whether this opinion is right or wrong, future tree generations are undoubtedly safeguarded by removal of individuals which have proved to be susceptible.

FIG. 10. CORRECTION BY PRUNING
EXUBERANT BRANCHING IN VIGOROUS YOUNG DOMINANTS CAN BE CORRECTED BY PRUNING EARLY IN LIFE. THE TREE IN THE FOREGROUND HAS BEEN PRUNED AND LATER ADDITIONAL LOWER BRANCHES WILL BE REMOVED.

Where provision must be made for natural regeneration, trees which bear evidence in the form of cone litter of having borne abundant seed crops in the past are selected as seed trees. Large, mature trees, even though it is probable that they will blow down or be struck by lightning, are left for seed, when needed, if the ground underneath them is blanketed with cones representing several seed years.

Improvement measures are obviously more effective in young than in old stands. Removing a large wolf tree after it has suppressed its smaller neighbors, or removing a mistletoe-bearing tree after infection has spread to neighboring groups of saplings, is much like locking the garage after the tires are stolen. In a well-managed forest there are usually large numbers of seedlings, saplings, and poles, in addition to the relatively large trees left in selective logging. Many individuals in this younger generation may be of undesirable type, and whether a product of heredity or of environment, they should be removed when they interfere with trees of a better type. Some vigorous growers which, though of good form, tend toward excessive branchiness can be improved by pruning off the lower branches in order to form clear boles (Fig. 10). Treatment of young stands by eliminating undesirables and pruning selected crop trees is called stand improvement. In Europe it is considered good practice to bring young forests through the sapling stage in very dense stands, then thinning from time to time by removing the less desirable stems and leaving the better ones. This program provides large numbers to select from and results eventually in a stand of superior trees correctly spaced. Stand improvement is essentially a means of directing and aiding natural selection.

To summarize, forest genetics, or tree breeding, may be practiced by two general methods: artificial propagation of hybrids and selective improvement of natural stands by consistently favoring the better types at the expense of those less desirable. The first method can be applied only in artificial regeneration or where treeless areas are forested by planting. Under these conditions the method has great possibilities, but it must necessarily proceed at a slow rate because planting is tedious and expensive. The second method deals with natural forests and therefore has wide and immediate application. Both methods have their place. Neither one has received the attention it deserves in this country, because forestry hitherto has been concerned primarily with the harvesting of native wood crops which could be had for the taking. But the time is not far distant when this Nation's timber supply will be limited to what is grown. Availability, quality, and cost will be determined by the efficiency attained in growing the crop, and in this process genetics is destined to assume increasingly great importance.

MINING TERMS OF OBSCURE ORIGINS

By EDWARD TAUBE

INQUIRY, over a period of years, into the derivations and associated historical details of scientific terms listed in the dictionaries as "obscure," has led to the following discussion of five mining terms.

MATTE

Metallurgists apply the word *matte* to the impure metallic mass formed in the initial stages of the smelting process. In our day it calls to mind the huge quantities of nickel *matte* treated at Sudbury, Ontario; but when it began to make its way into French and English dictionaries, during the nineteenth century, it had already fixed its abode in the Harz Mountains of Germany, in Saxony, and in adjacent mining regions. There, under different spellings and a wide variety of meanings, it had for hundreds of years been familiar to early German miners as well as to the populace at large. After 1171, which marks the discovery of silver in the Saxon hills, Freiberg took on the outstanding position in mining and metallurgy that it held for centuries. Its famous penal code of 1294 decrees the death penalty for anyone found guilty of minting coins with improperly purified silver, with *mathan,* and a milder punishment, the loss of the right hand, if iron is the impurity. In the second half of the sixteenth century Johann Mathesius preached at Joachimstal in the Erzgebirge, a town best known to us because the distant ancestor of our dollar was minted there. This theologian's sermons have appeared in print and constitute valuable source material for the study of early mining methods and mining terms. He speaks of *maute* (heap of ore) time and again.

Among the senses that this noun of ancient lineage and numerous relatives attained throughout Germany and many parts of Europe were "mud," "brass," "peat," "clod," and "bank of earth." The place-names *Motta* and *Cimalmotto* (*Schimmelmutt,* mold dirt) show that its range extends as far south as the Italian part of Switzerland, and *Mutta* can be seen in Canton Bern, Graubünden, and Solothurn.

Few chemists as yet realize that *matte* is hidden away in the second element of our *bismuth,* a term which has been subjected to much unsatisfactory inquiry. Early references to the metal are most frequent in the works of Georg Bauer (1494–1555), famous as Agricola, the first great expert on mining and metallurgy. In his works, which were written in Latin, he reduced to scientific order the knowledge he had acquired from the miners at Joachimstal in the Erzgebirge, and at Chemnitz in Saxony. This eminent mineralogist often mentions *plumbum cinereum, bisemutum,* and *wismut,* so for instance in the glossaries of *De Re Metallica, Libri XII* (1556), where he records the German equivalents of the Latin terms. The English language now uses *bismuth,* with a *b* replacing an original *w,* a change suffered by a considerable number of words in the mouths and under the pens of Agricola's countrymen. German chemists of our day write *Wismut,* though occasionally also *Bismut, Wiesmat,* and *Wismat.* The term breaks down into the old adjective *wis* (*weiss,* white) and the noun *mutt* (matte, lump, clod). A touch of white appears in the native metal, and some of its ores and compounds show this coloration to a marked degree; for example, bismuth oxychloride and bismuth subnitrate. Standing alone, the noun could denote the metal too, if the information given in Harrison's *Description of England* (1587) is correct: "A metall more naturall, and the verie same which *Encelius* calleth *Plumbum cinereum,* the Germans, 'wisemute,' 'mithan,' &. 'counterfeie.' "

MISPICKEL

Arsenopyrite bears the distorted name *mispickel,* which we find mentioned in English mining literature for the first time in 1683: "All Silver Oars . . . free from Flint, Blent, Cobolt, Mispickel, Glimmer, Wolferan." The work carrying this quotation

was a translation of a German book by Lazarus Erker, chief assayer of the German Empire. The translator, who for many years was deputy governor of the Mines Royal Company, distinguished himself by the publication of several important metallurgical treatises. The spelling applied by Pettus can, of course, be seen in his German source, also in Mathesius's collection of sermons, which, in addition to *mispickel*, has *mieszpieckel*, *miszpieckel*, and *mispült*, and in Agricola's glossaries, which list *mispickel* and *mispückel*. Finding a derivation or selecting a correct form from so many variants would truly be a difficult task, if Agricola had not left us a *mistpuckel* too. This immediately brings to mind *Mistbuckel* (manure ridge). Such a name leads to two interesting conclusions. First of all, it proves that early metallurgists had noses sensitive enough to detect the garlic odor of the strong arsenical fumes emitted by arsenopyrite when roasted, and then it draws our attention to the matter-of-fact nature of early mining terms, which in some instances were taken from the barnyard.

Quartz

Explanations of the word *quartz* have been put forward for several centuries, yet not one has met with universal approval. The preacher Mathesius once again comes to the fore when German attempts to trace the origin are considered. He suggested that *Quarz* is a contraction of *quat* (bad) and *Erz* (ore). Here and there a mineralogist became a disciple of this view. Other Germans thought out their own derivations. One maintained that *Warze* (wart) was the original word, because of the warty appearance of the crystalline elevations. Another connected the term with *Zwerg*, as if a dwarf had by some means or other distorted his name into that of the most common of all solid minerals. French scholars are inclined to regard the Latin *quadratus* as the source, from the angularity of the crystals. Aside from pointing to the German origin, English dictionaries are for the most part satisfied with "doubtful," "etymology unknown," or "of uncertain derivation." One mineralogist is bolder than the lexicographers; he traces the word back to a German ancestor that suggests the sound of clay when kneaded. Such a large number of explanations, diverging so far and all seeking a basis in fact, should warn us against setting up a new interpretation before examining each and every pertinent detail with extreme care.

Scrupulous scrutiny reveals that *Quarz* was originally a variant of *Gries* (gravel). In some German localities it still means gravel. The question of form may be settled satisfactorily. Not only has a great German philologist, Jacob Grimm, expressly pointed to the replacement of a *k* by a *qu*, which permits *quarz* to evolve from the Old High German *crioz* (gravel), but modern German offers a number of words whose variants repeat the *grioz, crioz, quarz* relationship. *Gacken, kacken, quacken,* and *quaquen* (cackle) illustrate this sufficiently well.

The first German example turns up in a poem describing the efforts of a miner to obtain financial assistance from a local farmer. This interesting poem was written in the fourteenth century, either in Saxony or in Bohemia. Things are going exceptionally well at the mine, according to the sales talk:

> First-rate quartz and lustrous copper
> Accompany the gangue.
> It won't be long, if God so will,
> Before good ores we come upon,
> For quartz arranged in such a fashion
> Has never yet led me astray.

Impressed by the unfamiliar terms employed by the miner and misled by the glowing accounts, the farmer from time to time rendered financial aid, only to lose his total investment in the end, for no valuable ores were discovered.

The year 1631 marks the first appearance of the word in an English book, Jorden's work on spas and mineral waters: "Sparr, which the Dutch call Sput or Querts, shoots into points like diamonds." In order to appreciate the full significance of this passage, one must bear in mind that Dutch here means German, aside from noticing that names of minerals were often confused at that period.

Shaft

"Obscure origin" applies only in part to *shaft*, insofar as some authorities give due recognition to its German derivation, whereas

the larger dictionaries are silent on this point or are inclined to question an importation from the Continent. The famous *Codex Wangianus* contains decrees passed by the bishop of Trent in Tyrol for the purpose of regulating mining activities within his domain. Though written in Latin, it records several words of German nativity, among them *xafetus* in an entry for the year 1208. The monks of Durham, England, constructed a *shaft* for the mining of coal in 1433–34, according to their account books for that year. However, this method of mining may have been known earlier still, because an English monk who wrote in 1366 speaks as if he were acquainted with it. Even so, a sufficient margin of time remains for the loan-word to have crossed the Channel. As a matter of fact, German miners are reported to have been active in England as early as the twelfth century.

The phrase *sink a shaft* may be traced back to the Freiberg legal code of 1294. Section 2 of chapter 37 places all matters pertaining to the sinking of shafts in the hands of a special overseer. In 1583 Ulrich Frosse, a German, took charge of the mines at Perranzabuloe, Cornwall. Besides furnishing the earliest traceable English instance of *sink a shaft,* the letter which he wrote on the 27th of June, 1584, to Carnsewe, one of his backers, offers us an interesting specimen of early English mining literature:

> Wee have at this present gone vp with our newe abdite 10 faddem in the higher Close and Cliered the rouble out of on of the higher shafte aboue, and soncken downe, and so mean to Dryve upward and downe ward, and in sincking thes two shaftes in the higher Clos wee did light with great boules of water betwixt the shafts in the higher old abdite a mongst the rouble, which the shaftes dothe stee, because the shaftes was fuled up with rouble higher then the old abdit is, whereby the water in the old abdite betwixt shaft and shaft is steed, and hath put us to much troble untill hither to, which nowe wee have brought dowen.

Shode

Shode (*shoad*) is weathered ore that has been washed away from an outcropping vein and has been deposited in surface debris at some distance from its point of origin. Here again we have a German mining term.

Repeated entries in state documents show that different rulers encouraged German experts to develop English mining. These came, bringing their special skills and an extensive vocabulary, for Germans were then the exponents of the best mining practice. Hermann de Allemania, Thomas de Almaigne, and Tilman de Cologne are mentioned in the records of the fourteenth century. The high point was reached in the sixteenth century, with Hochstetter digging for copper near Keswick in Cumberland, Schutz erecting improved furnaces with bellows at Beauchief in Derbyshire, and Kranz building a smelter at Larian in Cornwall. *Shode,* which is still prominent in Cornish mining literature, owes its introduction to these experts from Central Europe. First the prospector sought out the heaps of debris in the valleys. Upon locating a *shode* with a favorable mineral content, he tried to guess from the conformity of the ground the direction from which the flood had come that had washed down the deposit. Then he began his search for the metallic veins. While Frosse was digging at Perranzabuloe, Carew was busy compiling a description of Cornwall. His book, which came out in 1602, devotes special attention to tin-mines and the methods employed in finding the ores: "They discover these works, by certain Tynne-stones, lying on the face of the ground, which they term *Shoad,* as shed from the main Load, and made somewhat smooth and round, by the waters washing and wearing."

An interesting record exists of an accusation brought in the middle of the fifteenth century by the prioress at Freiberg against a former mayor of that city. He, so runs the complaint, allowed the moat to deposit its *schute* onto a meadow, thus spoiling its value to the nunnery. Along the course of the Danube we come upon a different spelling of the same word. Below Pressburg the river, whose banks are here quite low, divides into several arms. These form two islands, the *grosse Schütt* (large shode), which is 56 miles long and 31 miles wide, and the *kleine Schütt* (little shode), about one quarter the area of its partner. The shifting sandbanks off the islands are a constant menace to navigation.

THE NUTRITION FOUNDATION

By CHARLES GLEN KING

THE Nutrition Foundation was organized two years ago by leaders in the food industry as an expression of their confidence in the long-time value of fundamental research and as a sincere acknowledgment of their responsibility for the protection of public health. The entire program is one of public service in a very real sense. Although the plan of organization may be regarded as new in several respects, the underlying principles on which it is based have been well established, we believe, in research experience.

BACKGROUND

The background of thinking that led to establishing the Foundation involved the following considerations.

A large proportion of the world's exploratory or fundamental research has been, and will probably continue to be, carried out in university research centers. Direct support of specific projects planned by the best men in these centers is probably the most economical way to foster pure research. Such work should be planned and published without regard to the special interests of an individual firm or of any agency that could bring a bias into the picture.

The current trend in American economic affairs has led to serious shrinkage in the income from invested funds. Universities, hospitals, and other endowed institutions will be correspondingly handicapped; hence large-scale corrective measures should be introduced promptly to offset this effect, or the entire social order will suffer. As an illustration of what has happened, President Walter A. Jessup of the Carnegie Corporation recently reported that their income from invested funds had dropped from 4.5 percent in 1932–33 to 2.7 percent in 1942–43.

The trend in tax policies makes it unlikely that individual citizens will find it possible to accumulate large fortunes with which to support or endow universities and other research organizations as they have in the past.

The prospect of increasing government supervision and financing of our educational and research centers—which means, indirectly, increasing political control—presents a picture that calls for careful consideration. Granting that government support of research and education is wholesome and desirable, many citizens feel that these areas of our social order should not be completely dominated by political agencies. The spirit of freedom and initiative is nowhere of greater importance than in the field of scientific research and education. A man's independence in his search for scientific truth is about as fundamental and as sacred as his freedom to develop his own religious life. Therefore a judicious balance of independent support is desirable in these areas, in parallel with state support.

Only a few industries have been able to provide for extensive research programs of a fundamental or exploratory type within their own organizations. Nearly everyone is familiar, of course, with the notable research conducted by the General Electric Company and the Bell Telephone Laboratories, but even such fine developments as these do not, in a broad sense, take the place of our universities. Nevertheless, industrial leaders have developed an increasing appreciation of the contribution that unrestricted fundamental research can make to industrial development and stability, as well as to the community at large.

By joint action the representatives of an industry can accomplish a number of things that would scarcely be possible otherwise. They can give a research program a degree of objectiveness and independence that a single firm could scarcely provide. They can organize broad, long-time research programs involving a number of universities working cooperatively. They can cooperate effectively with the leading research men of the entire country, including Canada, in committees for developing advisory services and for direct cooperation in research. They can foster good will and cooperation within

the industry, and their forthright, public spirited action in supporting the Foundation's program cannot escape public recognition and the development of good will toward the entire industry.

Organization

The financial plan for the Nutrition Foundation is apparently new in some respects. The entire approach to financing is on the basis of a continuing program, projected five years in advance.

On becoming a member of the Foundation, each firm agrees to make its contribution on a five year basis, and all funds received by the Foundation are scheduled accordingly. As new members come into the Foundation, the program can be enlarged, but the Foundation is continuously assured of at least a minimum budget through the five-year period. Therefore commitments on research projects can be made for as long as five years when necessary—and *in basic research it is often necessary.* Many of the firms have paid their entire commitment during the first or second year. This policy is encouraged for two reasons: advance payments will serve as a cushioning fund against years when current earnings may be low; and by paying the five-year contribution in full, future officers or directorates are not subjected to a binding commitment of their predecessors. Contributions, but not pledges, to the Foundation can be deducted in full against taxation.

Each year the member firms are invited to extend their pledge an additional year, so that the Foundation is not placed in a position of going ahead full steam for a five-year period, with a risk of approaching collapse toward the end of the first five years. There has been a good response to the need for maintaining this projected basis for planning. Nearly all the original members and most of the new members have extended their pledges into the sixth year. The total sum pledged to the Foundation is now $1,428,000. Of this amount, $526,600 has been paid out in research grants.

In selecting the Board of Trustees, which is the governing body, a number of outstanding men were invited to serve as representatives of the public; among these are the Surgeon General of the United States Public Health Service and five university presidents. The public members of the Board are: F. G. Boudreau, Cason J. Callaway, O. C. Carmichael, W. C. Coffey, Karl T. Compton, Charles Wesley Dunn, Father Hugh O'Donnell, C. G. King, Thomas Parran, George A. Sloan, Ray Lyman Wilbur, M. L. Wilson, and Stephen S. Wise.

Recognizing the public service nature of the organization, these men have attended meetings of the Board regularly and have shown an intense interest in what we are doing. Karl T. Compton, President of Massachusetts Institute of Technology, is Chairman of the Board, and George A. Sloan of New York is President.

An important part of the organization is the Food Industries Advisory Committee. These men serve both as an advisory group to the Foundation and as a means of maintaining contact between the Foundation's program and the technical staffs of the member firms. In most cases the members of this committee are Directors of Research or Chief Chemists. The committee does not attempt to serve as a referee body or to pass upon specific grants, but the members play a very important role in building and guiding the organization. On them rests the practical and difficult task of providing the food that the public needs.

Specific direction of the research program is in the hands of the Director and a Scientific Advisory Committee made up of fifteen outstanding research men, most of whom are in university positions. The group was selected primarily upon the basis of accomplishments in pure research, but of course some consideration was given to the need for different points of view, such as clinical or medical nutrition, agriculture, physiology, public health, the armed services, and the broad field of biochemistry, in which most of the fundamental research on nutrition is conducted. The committee meets at least twice each year for group discussions, and is frequently called upon by correspondence. No recommendations are made to the Board of Trustees regarding grants of any kind without first receiving a favorable ballot by this committee. The program is thus kept completely independent of any one person

or firm, and there is a forthright commitment to make the funds as effective as possible in the development of a long-range program of fundamental research and education in the public interest.

All these committeemen serve on a voluntary basis, in the same spirit with which they would accept responsibilities in scientific societies.

Grants are made only to universities or to similar research institutions in the United States and Canada where there are opportunities for outstanding research. To 41 different institutions 87 grants have been made. In many instances there is close cooperation between men in different institutions who are working on special phases of broad problems. The grants range in size from $250 to $12,000 per year, and from one to five years in duration. Projects that develop especially well may be expanded. The largest single increase in 1943 was from $3,600 to $12,000. Many of the grants are in the range of $2,400 to $3,600 because such amounts will provide for well trained post-doctorate research fellows. It is our feeling that funds in support of graduate student and post-doctorate research fellowships, when supervised by men of outstanding attainment, will generally contribute most effectively to the development of pure research.

Program

For the present, projects that contribute to meeting the war emergency have first preference; for instance, research directed toward improvement of performance in tropical warfare, aviation, recovery from wounds and shock, and protection of civilian health. Specific examples of the Foundation's projects are given below.

Exploratory or more fundamental studies. Probably no other project is more characteristic of the Foundation's program than Rose's work on the human protein requirement. It is unusual to have a single project so deserving of recognition in relation to all three phases of our program; namely, war work, public health studies, and purely exploratory research. Giving sharp definition to the human protein requirement, his current studies follow logically upon his classical studies during the past twenty years with albino rats. Closely related work is under way at Johns Hopkins University, Wayne University, and the University of Rochester.

A second group of projects is concerned with basic problems in animal and human physiology. In time these studies will give information concerning the types of functional breakdown that are so prevalent beyond middle age. The projects at Yale University and at Memorial Hospital in New York deal specifically with the role of diet in warding off cancer. Duryee at Columbia University is studying the relation of food intake to the strength of the blood vessels and the related resistance to shock. Projects dealing with liver and kidney function, from a chemical point of view, are being directed by du Vigneaud at Cornell University, Hoagland (Rockefeller Institute) and Ralli at New York University, Luck at Stanford University, and Hodge at the University of Rochester.

In normal experience, more than half of the human body's total energy is derived from the burning of carbohydrates, or sugars. In addition to providing a source of energy, such metabolism is basic to our whole body economy, including muscles and the specialized brain and liver cells. A better knowledge of such changes is certain to improve medical practice, as in dealing with diabetes, and it would be extremely helpful in understanding military, aviation, and industrial fatigue. Grants in support of such studies have been made to Hastings and Westerfeld at Harvard University, to Stotz at Cornell University, and to Clarke and Stetten at Columbia University. Earlier basic studies of this nature now contribute to better aviation performance as well as to medical practice.

Other grants in support of exploratory types of research deal with such problems as: the isolation of new vitamins; the biological function of mineral elements, such as iron, copper, and calcium; the development of accurate methods for measuring the nutritive value of proteins and vitamins; the isolation of the catalysts that control combustion reactions in the body; and the search for a reliable yardstick by which to measure the food intake—in other words to find the optimum levels of all nutrients that are essential.

Projects related closely to public health. The medical profession is beginning to feel confident that clinical or human nutrition has enough scientific standing to be recognized as a field for professional specialization. Nearly every alert school of medicine and school of public health is now scouting for properly trained young physicians to build a teaching and research division of nutrition.

A grant of $7,500 per year for three years was made last summer to aid Vanderbilt University in building up a strong nutrition center. The project is supported jointly by the Rockefeller Foundation, the State Department of Public Health, and the Nutrition Foundation, and it involves cooperation between the medical school and the public health services. Harvard University receives $5,000 per year to assist in the training of young physicians in the science of nutrition.

The nation is gradually awakening to the seriousness of our ignorance regarding tooth decay. It was shocking to find that among the first two million men called to military service, dental defects were responsible for one-fifth of all the rejections. Hence Elvehjem at the University of Wisconsin was given assistance to undertake a carefully planned study of the relation of nutrition to dental caries. For the time being he is placing special emphasis upon studies with monkeys, because they are the only animals similar to man both in nutritive requirements and in the development of their teeth. Projects at the University of California, Yale University, and the University of Rochester supplement the work of Elvehjem's laboratory.

In Detroit Hoobler is studying the composition of mother's milk as a basis for improving the diet of mothers and infants. At Cornell University Maynard has organized a parallel study of the composition of cow's milk. The combined studies will establish a chemical basis for modifying cow's milk when mother's milk is not available. Both groups are collaborating with Longenecker of Pittsburgh in making a detailed study of the fats in milk.

Warkany at the University of Cincinnati has found interesting leads regarding the effect of the mother's diet upon malformations in the offspring. Such deformities as cleft palate, poorly formed jaws and spines, and missing toes are induced in experimental animals by poor diets; and, more important, they are prevented in large degree by good diets. There is genuine interest in the possibility that these findings will explain some of the deformities in human offspring.

Cerecedo at Fordham University is studying the relation of good nutrition to the capacity for lactation in experimental animals. This work in New York and the foregoing studies in Cincinnati, Ithaca, and Pittsburgh, all add elements of strength to the observations on maternal and infant nutrition at Detroit.

At McGill University, Struthers and Hunter are undertaking a study of the protective role of good nutrition against rheumatic fever in children. Coburn, whom the Foundation is helping at Columbia University, has been getting very encouraging results in preventing the recurrence of rheumatic fever in children by means of good food. It should make a fine contribution to better child health if Coburn's work can be confirmed and extended in the Canadian laboratories.

Illustrative data (Table 1) taken from a recent paper by Burke, Beal, Kirkwood, and Stuart of Harvard Medical School, point

TABLE 1

RELATION OF HOME FOOD PRACTICES TO MATERNAL AND INFANT HEALTH, BASED UPON 216 CASES, OVER A PERIOD OF TWELVE YEARS[1]

Mother's diet	Infants classed as "superior"	Infants classed as "poorest"	Incidence of pre-eclampsia among mothers
	Percent	*Percent*	*Percent*
Good or excellent[2] ...	56	3	0
Fair ...	35	18	8
Poor or very poor[3] ...	9	79	44

[1] These studies were conducted before the Nutrition Foundation was organized.

[2] Approximately the levels recommended by the Food and Nutrition Board of the National Research Council, 1943.

[3] Approximately 40 to 60 percent of the Recommended Dietary Allowances of the National Research Council.

convincingly toward the contribution to public health that good nutrition can make in America.

Publications. The only publication supported by the Foundation is a new journal, *Nutrition Reviews.* Its purpose is to make available to physicians, teachers, public health workers, food technologists, dieticians, and others who are professionally responsible to the public, a critical, unbiased review of the world's current literature in the science of nutrition. The editorial staff is selected from experienced, independent research people. Paid subscriptions to the journal have grown steadily, without any promotion or advertising, at the rate of over fifty new subscriptions per week, the total exceeding 3,500 within the first year. A Portuguese edition is now published in Brazil, under the supervision of Dr. J. De Castro.

A byproduct of membership in the Foundation, in a number of cases at least, has been to increase the support of research by member companies within their own organizations. At each meeting and during intervening discussions, I believe that the trustees of the Foundation see more clearly that research should have both immediate, or applied, and exploratory aspects, and they are increasingly sympathetic toward long-time objectives in nutrition research.

No doubt each industry will approach its support of research from slightly different angles, but thus far no serious flaws have shown up in the pattern of organization of the Foundation. Within the past few months, the Sugar Research Foundation and the Refrigeration Research Foundation have been established along similar lines, but with greater emphasis on applied research. Several other industries have comparable plans under consideration.

Each grant made by the Nutrition Foundation is an investment in better public health, more intensive training of young people in research, and a higher level of public service on the part of the food industry.

THE INCENTIVES OF SCIENCE

By C. JUDSON HERRICK

THE annals of science, of art, of industry, and of philanthropy record numberless instances of persons who have sacrificed their own profit and comfort, and even family welfare, to an ambition which to the more practically minded may seem visionary, perhaps even fanatical. When Palissy, the potter, burned the family bedstead in his furnace to salvage an experimental enamel and when Walter Reed's heroic band voluntarily inoculated themselves with yellow fever to test a theory, these men were not motivated by craving for fame or hope of royalties that might accrue from their discoveries. They wanted to know something, and no price was too high to pay for this knowledge.

This craving for knowledge is the basic motivation of all great scientific work and, accordingly, modern science has elaborated a code of procedure designed to check the accuracy of our knowledge in every practicable way. The accumulation of factual data is made as complete and exact as possible, and the validity of every fact is checked against its congruence with all other relevant experience. This body of verifiable facts bulks so large as the foundation of all science that science is often defined as factual knowledge systematically organized, and nothing else.

This conventional code, like every other formal Credo, misses the crucial issue. It substitutes static intellectual belief for the vital process of productive activity. Science is not a dead structure erected upon this or any other foundation. Factual knowledge is only the substrate from which living science grows, and when growth stops science withers and what remains is dogma. No single fact or principle of science may be accepted as absolute truth. Our "laws of nature" are all subject to revision in the light of new evidence. A dogma held to be final may obstruct progress for centuries, as happened in the case of phlogiston and the indivisible atom.

Living science does not grow by accretion of facts, as a glacier is enlarged by precipitation; it grows by intussusception like every other organism. When new facts are fitted into the growing structure, the pattern of the structure itself may be changed as radically as is that of the tadpole when it becomes a frog. This happened, for instance, at the time of Copernicus, and in our own day quantum mechanics is activating a similar metamorphosis.

Traditional dogma is as treacherous in science as in philosophy and religion. Our slogan is: what is the evidence? The printer's rule, "Follow copy if it goes out the window," may be recast—"Follow the evidence come hell or high water." But the meaning of a fact, say the spectrum of a star, may be quite different now from what it was before Einstein. Facts have meaning, not in themselves, but only for people, and when people change as their experience is enlarged, the principles of science reflect this change. For science is made by people. It is a growing thing because the people who create it are growing, and science grows by its own internal agencies in just the same way. A search for eternal verities by the scientific method is a vain quest. At present the principles of relativity dominate the picture.

The implications of this way of looking at science involve drastic revision of some of our most cherished dogmas. If science is motivated and quickened by human interest and if its pattern is designed in terms of ever widening human experience, then to dehumanize it is to kill it.

The devotees of science—I mean so-called pure science—who live perhaps with their heads in the clouds, are the pilots of our destiny; but they are not flying blindly. The course must be charted with reference to known and stable landmarks on the ground, if not by eye, then in some other way, perhaps by faith. But this faith is not blind. It is guided by rational interpretation of previous experience with the realities of things as they are. Without these contacts they lose their way and perhaps crash in disaster. Scientific truth is appraised in

terms of its meaning for people who live on the ground and who must adjust their lives to the terrain where they make their livings. Facts have no meaning for us except as means to an end, the objective being survival and getting as much satisfaction out of it as possible.

It follows from this that we must give up the notion that science is a body of objective facts and impersonal abstractions. It is intensely personal, for there is a person at the focal point of every great discovery and the discovery itself is a reflection of this personality. It is significant only to other persons and what that significance is depends in turn upon their own personal experience and qualifications. It has meaning for any one only in terms of his own pattern of life. Some of the most futile people I have ever known are very learned men, stored with vast accumulations of knowledge, none of which is of any significance for them or anybody else because they cannot articulate it with the pulse of life as it is actually lived.

The achievements of science and its technological applications have enormously increased the production of goods, with corresponding enlargement of wealth and opportunity for better standards of living. But at what cost? Clever mechanical devices perform our menial tasks and thus free our hands for more satisfying activities. But what use are we making of this gift of leisure? Do these gadgets which save time and almost annihilate space really yield those values which make life more satisfying? That depends on the quality of the people who use them.

There are many who claim that the encroachments of science resemble cancerous growths that threaten all human values and virtues. Bertrand Russell has said, "The sphere of values lies outside science," and when science "takes out of life the moments to which life owes its value, science will not deserve admiration, however cleverly and however elaborately it may lead men along the road to despair."

Science has been accused of many crimes of which it is quite innocent, but here is a place where past failures are discreditable. Our failure to readjust the objectives for which we work and the methods of operation so as better to serve the major human issues now before us in the management of our personal affairs and social relations has tragic results. The responsibility for this failure to meet urgent opportunities and obligations lies with men of science themselves. Here I speak with deep conviction and, as a contrite sinner, with great humility. We men of science have failed to appraise our own values intelligently and to instill them into our pupils as skillfully as we might, had we tried harder to do it. Too often we have stubbornly refused to admit the truth recently voiced by a sociologist, that "values represent no special or unique problem in the social sciences" and that science—all science—can practically deal with human values and does so, whether we acknowledge it or not.

Bertrand Russell truly says that the tradition of our cult is that the sphere of values lies outside science. If this tradition must be complacently accepted, I should be inclined to agree with him that such a science "is incompatible with the pursuit of truth, with love, with art, with spontaneous delight, with every social ideal. . . ." But this is a hideous caricature of actual science. It is false to the history of science, to present practice, and to our hopes for the future. When Ogden and Richards say that "scientific meaning is a pure pointing to things without attitude or indication of behavior," this is to throw into the discard the vital germ of untrammeled imaginative thinking, leaving in our hands only the dead husk that can be so easily weighed, measured, classified, and then stowed away in the warehouse as a museum specimen or a printed document.

If science had no interest in human values, there would be no science at all. Nobody would devote his life to the investigation of fundamental problems of no obvious immediate practical significance if he did not feel that he was getting something worth-while. The expenditure of long hours of gruelling toil must yield some return which is considered of sufficient worth to justify the cost. These values cannot be ignored by that science which is motivated by them. They are not decorative accessories of scientific work; they are intrinsic components of science as

it is actually practiced. This is true in all fields of science, and when we look at the social sciences we find these human interests and values at the core of every problem. Here the past failures arise from failure to recognize this obvious fact. We can never hope to find the answers to the questions of most vital concern to us by ever so clever an application of a scientific method which excludes the essential features of the problem from its formulation.

Values belong in science because they belong in nature, not only in human nature, but in all animate nature. Some of our most expert philosophers describe a value as a polarized relationship between a living individual and the object of interest, craving, or need, from which it follows that "satisfaction is the touchstone of value" (Santayana). Now, all animals have needs and all animal behavior, including human conduct, is an expression of the "satisfaction of the motivating conditions" (H. A. Carr). This satisfaction is a value, whether it is achieved unconsciously, as in reflex, or by intelligent purpose, as in making a dinner or painting a picture. There is, then, in nature a hierarchy of values, from elementary survival value common to all living creatures up to human desires, hopes, and aspirations. These values motivate conduct; they inhere in all vital activity as such. Let us then leave our values where we find them, in the natural world, and then in terms of actual experience with them try to sort them out and to appraise their relative worth in adjustment to life's situations as they arise.

The advancement of science will go faster and further if we attend to these intrinsic values sympathetically and constructively. This may require more of insight and courage than some timid laborers can command, but these "hodmen of science" are not the architects of our destiny. It is, I am sure, a practicable enterprise to write a natural history of values along the lines suggested, and the preparation of such an essay would be good sport for a qualified naturalist.

This view of the place of value in science I can document from my own personal experience in scientific investigation. As a biologist I have consumed a considerable quantity of good white paper recording my observations and reflections upon them. Why? Well, for one thing, because I like to do it and get satisfaction from finding out things about my own body and how it works. And also because I think that this knowledge is good for me and for all other people. If I did not feel this way about my work, I would not do it, but would earn my living in some other way. So I am looking here at the life of science and the aims and methods of science from the inside of the workshop, from the standpoint of the man who is doing the job.

Toward sundown as I look back over the day's work it is natural for me to ask, "What is the good of it? Does my business pay? If so, in what coin?" I am speaking now, not of my job as a teacher, for that business I am sure is profitable. Good teaching perhaps yields larger returns in public welfare and personal satisfaction than any other job on earth. I believe in it and I like it. But a large part of my time and energy has been devoted to scientific investigation, and for this also I have been well paid. After more than fifty years of intense preoccupation with these studies, none of which have any immediate practical applications, it is fitting to inquire whether the investment has yielded adequate returns.

In science we are searching for the truth, searching with singleness of purpose and with all our might. This search costs time, effort, and money. Now we are solemnly assured by eminent authorities that in this search human interests and values have no place. If found at all, they are by-products or a contamination. The ideal of pure science which has been set before us is so refined—"truth for truth's sake"—that the values are swept away in the flux as dross to be thrown out or turned over to technology. Out of this slag applied science may make a fortune, in cement or something, and pure science has left—a truth. And science is content, perfectly satisfied.

But something is wrong here. Satisfaction is a value, so our philosophers say. Maybe the truth is valuable; it is certain that it often gets us out of tight places. Puddin' head Wilson's advice is safe, "When in doubt tell the truth." So when science

in her disdain of values achieves a truth and finds satisfaction, she automatically creates value in spite of herself.

These values of pure science are so inextricably intertwined with those of applied science that the old distinction between these two fields has faded out of the picture. We are reminded of Karl T. Compton's acute comment that science provides "a way of securing a more abundant life which does not simply consist in taking away from some one else. Science really creates wealth and opportunity where they did not exist before . . . a cooperative creative effort in which everyone is the gainer, and no one the loser."

When these teachers of philosophy and scientific method assure us that science knows no values, just what do they mean? Well, for one thing they would impress upon us that the first task of science is the orderly arrangement of the facts of experience into a coherent system of knowledge. The ideal held before us here is an impersonal and unprejudiced judgment in the separation of the true from the false and the systematic arrangement of the facts discovered, stated so far as possible in quantitative form. From the uniformities thus revealed the so-called laws of nature are formulated, not as personal opinions, but as verifiable objective descriptions of natural things and events. In this first task the most treacherous of all subversive enemies of sound scientific progress is the bias arising from unrecognized personal attitudes, interests, and preconceptions. There is a "personal equation" here which never can be completely eliminated. The best we can do is to try to recognize it and make due allowance for it with all appropriate checks and counterchecks.

So far we are on safe ground. There is general agreement that this is sound scientific method. According to the generally accepted code this is all there is of science; its task is finished. This I deny and maintain that this first step has merely laid a firm foundation for further building. Science is unfinished and indeed futile until the superstructure is added. We want to know what these facts mean, not to some detached omniscience, but in terms of actual human interests and problems of adjustment.

Attention has already been called to the joker concealed among the building stones of the factual foundation, for this knowledge of facts and principles so laboriously acquired is all derived from human experience; no other kind of evidence is admissible according to the code. And experience is always experienced by somebody with human interests, limitations, and imperfections. The easy way out of the difficulty is to ignore the troublesome personal factors, but actually this cannot be done, and we cannot afford to try to do it, for, as already pointed out, the interest and attitude of the investigator are key factors without which an inquiry would not be made in the first place and the result would be fruitless in the end.

No, this is not the way out. It is as important in scientific research as in teaching that the facts have meanings. Until these meanings are revealed, either by the discoverer of the facts himself or by some successor, the accumulated knowledge is a token of potential value like gold dollars stored in a government vault. So long as it remains in the vault it has no value except as reserve. To be productive it must be put in circulation. So knowledge which does not touch human life would not be worth anything. The saving feature of this situation is that all knowledge does touch life. Sooner or later it will be fitted into place as part of the armamentarium of successful human adjustment, so that our stores of even apparently useless knowledge comprise a valuable reserve upon which drafts are constantly drawn in the promotion of new enterprises. All advance in pure science and most of the inventive marvels of applied science are directly dependent upon these stores of accumulated knowledge, much of which was acquired with no expectation of immediate practical application. The investment is sound because the token represents real value as soon as it is put into circulation.

The conclusion is that the natural sciences are afflicted with the same malady which has recently been diagnosed in the humanities. It is not a paralysis which inhibits activity, but a defect of vision, of that inner vision that we call insight, which confuses the vital issues. It is not like a cataract that obscures

all vision; it is a mental squint complicated by myopia, scotoma, and astigmatism, resulting in distortion of everything in the field of view. This has a shocking sound and it really is bad because, though we may be going very fast, we do not arrive anywhere and we stop before the job is finished.

The ultimate aims of humanistc and scientific activity are the same—to enrich life and enhance its satisfactions—but as we take our devious ways, blazing trails through the untrod wilderness of unpredictable and confusing new experience, attention is distracted by interesting detail on the way and the primary objective is lost to view.

We want something better than what we have now, and we want to be better than we are now. But what is better? There is only one way to find the satisfying answer. Not by wishful thinking, not by disputation about transcendental mysteries of absolute truth, right, and perfection, but by actual experience with the various things that we prize and work for, measuring the satisfaction won by the price we have to pay. If content with shoddy values, life is shabby. It does not follow that the cheap values are most easily won, for a gaudy bauble may cost more than priceless treasure and our choicest satisfactions are free as air.

Of course pure air is not free if my neighbor fouls it with noxious fumes and it may cost me an expensive lawsuit to be rid of the nuisance. So every interest that we have is directly or indirectly tied into our social relations. In this soil we find the roots of altruism whose flower gives us our choicest satisfactions. As has often been pointed out, our moral values top the list even when viewed from the scientific standpoint, for social opportunities and obligations form the cement which holds society together. Without intelligent adjustment here civilization perishes and we perish with it. In the long view moral rectitude has actual survival value. This lesson, which all of us are slow to learn, is now being taught to some criminal aggressors the hard way.

Our standards of value, of what we prize and work for, have actually been built up in terms of human experience. The analysis of this experience in the light of what we want and what is available for its acquisition involves a judicious selection from among all the desirables before us. This judicial appraisal of our values is essentially a scientific problem. Science will not fail us here if we have the insight and the courage to follow whithersoever it leads, but it is powerless to help us in this quest unless released from those fetters of traditional dogma which hitherto have crippled its efficiency in this domain of major human interest. Only when science is keenly alert to its own values can it contribute anything toward judicious pursuit of other values. A science which renounces its own intrinsic values is blind and dumb in that domain where keen discrimination and courageous speech are most needed.

The cardinal thing about science is not its facts or its principles; it is its method of enlarging experience and solving problems in terms of that experience. Science is not an inert body of knowledge; it is a way of life. The life of science must not be confined in the ivory towers of academic seclusion nor within the soot-begrimed walls of industry. It must infiltrate, quicken, and guide every human enterprise. This requires trained and disciplined leadership by men of science who are willing and eager to accept, not only the opportunities given them by society, but also the social obligations which acceptance of these gifts implies.

The life of science is not all of life. The rare idealism which motivates production in research, in literary and artistic expression, and in philosophical inquiry is not a scientific product, a figment of imagination, or a religious dogma. It is the highest manifestation of life, of all of life and the fullness thereof. The task of science here is by honest inquiry in all humility to seek for guidance in the search for what is true, what is good for us, and what will make life richer and more satisfying.

SCIENCE ON THE MARCH

THE CAUSATION OF DISEASE

THE evolution of etiologic thought, like other evolutions, has been a long, slow, and often painful process. Primitive man, requiring some explanation for mysterious aches and weakness, sought solace in placing the blame on supernatural influences. This absolved him of responsibility for his own illness. Demonology, and later, Divine Wrath had their vogue as men shifted more and more responsibility from themselves unto God. Later came dim awareness of the relation of epidemics to certain environmental factors (the relation of malaria to swamps) and the appearance of many vague theories of "miasmata," "vapors," and "humors." Though there were glimmerings of the concept of contagion during the terrible epidemics of the Dark Ages, modern etiologic thought began with the epochal discoveries of Pasteur, and the birth of the new science, bacteriology.

Pasteur's discovery that certain diseases were due to invasion by microorganisms or bacteria was quickly followed by Koch's equally significant studies concerning the specificity of the organisms responsible for specific disease entities. Koch declared that the etiologic relation of a microorganism to the causation of disease was not demonstrated without fulfillment of the following conditions: (1) the microorganism is present and demonstrable in every case of the disease; (2) it is cultivated in pure culture; (3) inoculation from such culture must reproduce the disease in susceptible animals, and (4) it must be reobtained from such animals and again grown in pure culture. These postulates of Koch became the basic law of the new science. Feverish research, spurred by the hope that in this vast realm of pathogenic bacteria would be found the explanation of *all* disease, led to many brilliant and invaluable discoveries. One after another, the specific organisms of infective diseases were identified, isolated, and studied. The science of immunology developed as a collateral branch. Diphtheria, typhoid fever, the dread "summer complaint" of infants, plague, cholera, and several other diseases, were quickly controlled, once their infective origin was known. The causative organisms of many other diseases, such as tuberculosis, pneumonia, meningitis, gonorrhea, and syphilis, were also discovered, but effective methods of combating these infections are developing more slowly. Planned chemotherapy appeared with Ehrlich's studies on synthetic arsenical compounds, effective against the spirochete of syphilis. Only in the last few months, the various sulfa compounds and, still more recently, penicillin, have opened new avenues of attack upon the dread coccal infections. Refined laboratory methods have revealed the existence of the still more minute viruses, ultramicroscopic in size and apparently molecular in nature. The viruses belong in that hazy borderline between the living and the nonliving.

But the dreams and hopes of the earlier bacteriologists have not materialized. Invading microorganisms do not cause all disease, and even when they are involved, they are not the sole cause of infective diseases. The concept of specificity, though invaluable in preventing many hasty and erroneous conclusions, also blinded many scientists to the fact that disease follows only when the germ invades a *vulnerable* host. A seed in uncongenial soil does not flourish. It is only in the last few years that adequate attention has been paid to the condition of the host prior to, or during, bacterial invasion. Furthermore, some diseases are in no way etiologically related to infections. The search for microorganisms and viruses as causative agents in cancer has been extensive and painstaking; the results negative. Diabetes, arteriosclerosis, high blood pressure, gout, goitre, and many other so-called "degenerative" disorders arise without the slightest suggestion of infection as a cause.

But the idea of specific causation is not yet dead: a new menace has been discovered in nutritional deficiencies and there are those who now wish to attribute almost every human ill to nutritional defects. They too are doomed to fail, though from their failure

much good will come, for certainly *some* disorders are due to defective nutrition. Science is vulnerable to fads and fashions. We must be constantly on our guard not to be carried away by "fashionable" enthusiasms.

The essential message of this brief and obviously incomplete survey of etiologic thinking in medicine, is that *causation is always a combination of multiple factors.* Nothing happens from just a single cause. This is as true of wars, marriage, explosions, floods, or earthquakes, as it is of disease. It would be immensely beneficial to all our thinking if the singular of the word "cause" were deleted from our vocabularies, and the more flexible term "causative factors" used in its place.

Causative influences are amenable to analysis. They fall under three categories: predisposing factors, provoking factors, and perpetuating factors. These three types of influences are invariably present in the causation of any and all illness, although they are not necessarily of equal importance. Disease is comparable to the long famous illustration of the camel's spinal fracture; it was not just the "last straw" that broke the back of this unfortunate beast of burden, but this last whisp of cellulose *plus* all the previous load, which may have been straw or hay, or figs, or bricks, or harem ladies, or kegs of wine! And in no two instances were these predisposing factors necessarily identical.

We know that almost every adult bears the scars of healed early lesions of tuberculosis in his lungs, though he does not have, nor has he had, clinically active tuberculosis. The provoking factor, the tubercle bacillus, is there. Nothing serious happens because the factors predisposing to invasion are absent. The potentiality of disease, however, remains. Fatigue, intoxications, other infections, or exposures may so lower the barriers of resistance that the latent infection becomes active. Obviously, the condition of the host is equally significant with the presence of tubercle bacilli.

"The cause" of cancer will never be found, nor "the cause" of hypertension or arteriosclerosis. Modern researches are revealing more and more how complex are the interrelationships between constitutional vulnerability, exciting agents, nutrition, infection, intoxications, and perpetuating factors intrinsic in the pathogenesis of many chronic and progressive disorders. Bacteriology will not solve the riddles of chronic heart disease, arteriosclerosis, cancer, or diabetes. Nor will any simple formula, resembling the rigid dicta of Koch's postulates, apply to all cases of any one disease. The concept of specific entities and specific causes has been overworked. The degenerative diseases overlap; the etiology of each and every case, though following general patterns, differs in detail. What we are today is because of what happened to us yesterday. And each of us has had different yesterdays.

A more general appreciation of the significance of the above fundamental classification of causative factors, and greater individualization in etiologic analysis of instances of disease must improve medical practice. The significance of causation lies in the fact that effective treatment, whether preventative or curative, is predicated upon thorough elimination or control of causative influences. We can hardly expect to obtain a lasting cure of a sore heel, if we neglect the nail in the shoe.

EDWARD J. STIEGLITZ

PHYSICAL ANTHROPOLOGY AT WORK

How big is a big man? How little is a little man? How big is an average man? Big, little, average size must be known in absolute terms, but also proportions and body-types: Long arms or short? Long legs or short? Slender or heavy build? These questions are vital for plane and tank design, for clothing sizes, for oxygen masks, and for many other details involving Aviation and Army personnel and matériel. The answers are being worked out by the Matériel Command at Wright Field under anthropologists: Lieuts. Francis Randall, Albert Damon, Robert Benton, and Dr. Alice Brues.

The initial approach to the problems now being studied was a reflection of the fact that in this war aviation has come into prominence: flying suits and their numerous gadgets had to be sized precisely to fit into restricted spaces; escape hatches had to be scaled to body-size and build; most serious of all, gun turrets restricted personnel size.

It became necessary, therefore, to carry on precise and large-scale anthropometric studies of the physique of the young American males going in for pilots, gunners, and bombardiers.

The first problem successfully attacked was that of types of oxygen-masks. Heads and faces differ from man to man, so that a single standard size and shape could not guarantee the careful and necessary fit. As a result, a series of standard head-forms were established so that within each form-category there could be guaranteed a high measure of safety and precision.

In the study of size and build, standard for turret gunners, the anthropologists gathered not only an impressive array of statistical data, but constructed three lifelike and adjustable plastic manikins that could be sent directly to designers and manufacturers for test-construction jobs. Elaborate studies were carried out to test visibility factors in gun turrets, correlated with positional adjustment and range of vision.

W. M. KROGMAN

CONSERVATION OF RUBBER

As the necessity for conserving existing rubber articles continues, it may be helpful to review the properties of natural rubber, particularly those that have a bearing on its deterioration. Those who keep these properties in mind and take care of rubber goods accordingly can greatly extend the useful life of these articles.

Davis and Blake in *The Chemistry and Technology of Rubber* (A.C.S. Monograph 74) point out that oxygen of the air reacts with all soft rubber to bring about its deterioration. As this reaction progresses, the rubber becomes softer, losing tensile strength and elastic recovery properties; then it finally hardens. This reaction is hastened by increase in temperature, by direct sunlight (and to a smaller extent by diffused light), by tensional stresses in the rubber, and by contact with certain chemicals and metals, especially copper and its alloys and compounds.

To demonstrate the accelerative effect of sunlight on the rate of oxidation and consequent deterioration of soft rubber, the writer recently made the following comparative test: One strip of rubber was exposed to direct sunlight for two days; a second similar strip was not exposed to sunlight. Then both strips were placed for the same length of time in a bomb under high pressure of pure oxygen. At the end of the exposure to oxygen, the first strip had become hard and brittle, whereas the second strip was still soft and flexible.

Rubber is not only deteriorated by oxidation but is adversely affected by organic liquids. It is swelled and softened by petroleum oils, turpentine, chlorinated hydrocarbons, dry-cleaning and metal degreasing solvents, most vegetable oils, and some fats.

In recent years the compounding of soft rubber articles has been improved to a remarkable degree so that under favorable circumstances such articles give many years of service. Under unfavorable conditions of storage or use the rate of deterioration may increase tremendously.

The results of the unfavorable conditions just mentioned are commonly observed; for example, hardening of overshoes and raincoats stored in a hot attic all summer, hardening of rubber bands when left stretched around a bundle of papers or becoming sticky and then hard if left in the sun, cracking and failure of rubber boots along the creases after having been stored folded (the outer surface of the rubber at the fold is under tension), failure of rubber garden hose where it is frequently kinked near its attachment to a fitting or where it is hung over a nail, failure of rubber parts on household gadgets where the rubber is in contact with copper or brass parts, or swelling and softening from contact with oils.

Ozone has an exceedingly rapid cracking effect on soft rubber which is under even very slight tension. Ozone forms from oxygen around electrical equipment, particularly high voltage equipment.

Rubber is also subject to failure by "flex cracking," when subjected to continuous or repeated stresses.

One of the most useful of the properties of rubber is its resistance to abrasion. Vogt has attributed this to ". . . its relatively enormous capacity for storing energy. Its energy storage capacity to the point of rupture far exceeds that of any other material."

It is this property which makes rubber unique for tires for motor vehicles. However, tires do eventually wear out, and the wear is the result of abrasion. The rate of wear also will be affected by the chemical factors of deterioration mentioned above.

No authority has been found for the common assertion that tires will deteriorate faster in storage than if they are being used. It is true, however, that tires deteriorate even when they are not being used, and with *improper* storage and care they *may* deteriorate faster than with *careful* use.

The mechanical aspects of care of automobile tires are well known, if not always practiced, but the chemical aspects need greater emphasis. In view of the recognized destructive effect of sunlight on rubber, the writer suggests the use of shields or shades for tires parked in the sun. The shades could be made of fiber board of suitable shape and designed to fold for carrying in the car when not in use. Such shields might be distributed as an advertising medium by local or national advertisers.

The facts outlined above yield this brief admonition: *Keep rubber clean, cool, dark, and undistorted!*

Robert S. Casey,
W. A. Sheaffer Pen Company

CONDENSER PAPER

So widely has paper been used in the telephone plant, and so well has it performed, that even with the multiplicity of new materials available today, it would be difficult to replace. One of its most important uses is in condensers, those electrical "springs" which absorb energy on rising voltage and give it out on falling voltage. A condenser is essentially two sheets of aluminum foil separated by a sheet of paper; for compactness the three are wound into a roll. Returning to the mechanical analogue, the foils are merely bearing-pads to distribute the stress; the springiness is entirely in the paper. That places three requirements on the paper: it must absorb as much energy as practicable per unit volume, it must waste as little as possible in internal heat, and it must withstand the voltage without breaking down. In the first particular, paper can be greatly improved by impregnating it with chlorinated liquids and waxes, and such paper condensers with aluminum foil electrodes have served the purposes of the telephone plant adequately for a number of years in places where temperatures and voltages are moderate. However, as the demand arose for more compact apparatus and higher unidirectional voltages and temperatures, it was found from laboratory tests that this combination did not provide a comfortable margin of safety. A study was therefore undertaken to discover the causes of failure under these more severe conditions.

Two types of paper have been commonly used for condensers. One is a linen paper, which is chiefly pure cellulose; the other is Kraft paper, typified by the common brown wrapping paper of commerce and which contains relatively large amounts of lignin, pentosans, and ash. It had generally been assumed that linen paper, because of its purity, would perform as well as, if not better than, Kraft paper, but life tests at elevated temperatures, involving continuous comparative measurement of electrical leakage, showed Kraft paper to have a life of four or five times as long as that of linen paper.

On dismantling the condensers after or shortly before failure, decomposed areas were found scattered throughout the paper. These areas were brown and embrittled, giving evidence of partial carbonization, and such areas appeared much earlier in linen paper than in Kraft. Only at much higher voltages do the Kraft papers show decomposition in time comparable to that of linen paper at 120 volts.

To find the reason for the different behavior of the two papers was the problem that challenged research. Here were two simple structures having only three components, paper, impregnant, and electrodes, and both identical except for the paper, yet showing widely different characteristics. The first step was to determine the impurities in the decomposed areas of failed or nearly failed condensers.

To accomplish this, a microchemical technique was employed. A section of linen paper containing decomposed areas was covered with a sheet of indicator paper impregnated with barely alkaline phenolphthalein. The indicator was decolorized in spots cor-

responding exactly to the decomposed areas, demonstrating the presence of acidity. Another sheet of paper containing decomposed areas was similarly treated with a silver chromate indicator paper used in the detection of chlorides. This indicator gave a definite positive reaction for chlorides in the decomposed areas. This demonstration of the presence of acidity and the presence of free chlorides is, of course, equivalent to the demonstration of the presence of hydrochloric acid.

Since the condenser paper used in these studies was extremely low in chlorides (about .004 percent), it was obvious that the source of the chloride ion was the impregnating compound. It was known that such compounds decompose to give hydrochloric acid under the influence of the electric arc or strong ultraviolet light. It now appeared that they would decompose under the conditions existing in a condenser. Strong evidence has been obtained at our laboratories that this decomposition is activated by the aluminum electrodes. The primary decomposition, however, is very limited in rate and amount, and probably of itself would not be perceptibly harmful. The condensers can be heated for very long periods without serious degradation so long as no voltage is applied; when voltage is applied, however, rapid depreciation of electrical properties results. The process of this depreciation is pictured as follows: The minute quantities of hydrochloric acid liberated by the action of the electrodes alone are electrolyzed, aluminum chloride being formed at the aluminum anode. Aluminum chloride is well known to be a powerful agent for the degradation of organic compounds. The most important action of aluminum chloride in the condenser is to further decompose the chlorinated impregnant, providing more hydrochloric acid, which provides more aluminum chloride, and so on until failure. Despite this undesirable action of aluminum, it is in most respects superior to other metals available in foil form at reasonable cost.

Having formulated the above picture, it was time to return to the original question of what makes Kraft paper superior to linen in condensers of the type under discussion. Since the decomposition was a vigorous reaction of the self-accelerating type, it seemed likely that whatever Kraft paper was doing, it was doing during the early stages of the reaction, when small chemical variations might easily influence the whole course of events to follow. Hence, it was apparent that Kraft paper was able to absorb, neutralize, or otherwise inactivate, the small quantities of hydrochloric acid formed in the primary decomposition reaction. It was further apparent that linen paper was either incapable of this action or capable to only a limited degree. The experimental proof of this point was simple but convincing. It was found that if a certain amount of Kraft paper was immersed in any dilute acid, it would neutralize in the neighborhood of 0.05 to 0.10 milliequivalents for each gram of paper, three to four times as much as an equal quantity of linen paper. This experiment has been performed on scores of samples, and although both linen and Kraft papers vary in this property, the level for Kraft papers is far above that for the linen. It thus appeared reasonable to conclude that the papers, by serving as acid buffers, delayed the onset of decomposition, the Kraft paper for a longer period because of its greater capacity.

The acid neutralization by both types of paper was found to be explained by the familiar base exchange concept, the hydrogen of the acid exchanging for chemically bound metallic cations constituting the ash of the paper. The exchange capacity was found to be directly proportional to the ash after a small allowance is made for the inert ash, principally silica.

One might say that at this point the original object of the investigation had been achieved. Had the investigation stopped here, it would simply have explained an interesting phenomenon, but would have been of little practical value. As a matter of fact, the findings discussed above provided both the scientific foundation and the inspiration for further important developments. We were armed with new information concerning the deterioration under electric potentials of paper condensers containing chlorinated impregnants. Could not this information guide us to new methods of producing better condensers?

The various extensions of the original research will not be discussed in detail. It can be stated, however, that this phase of the program was successful; it resulted in condensers that will withstand accelerated testing conditions about 100 times as long as the early linen condensers. The new improved condensers are used by the Western Electric Company in equipment manufactured for the armed forces, on whose behalf these techniques and developments have also been made available to other manufacturers. Considering the severe service conditions to which military equipment is subject, it can be confidently stated that these developments have aided in the reliability of military communications.

D. A. McLean
Bell Telephone Laboratories

INSECT REPELLENTS

The public has been made so conscious of new insecticides, particularly DDT (p. 154), and of new methods of applying them, especially by the aerosol bomb (p. 342), that many people must think it essential to kill insect pests in order to protect themselves and their belongings against attack. On the contrary, it is not always necessary to slay our six-legged competitors in order to overcome them, and sometimes it is even undesirable to do so if their presence is not annoying. For example, few people would be distressed by the sight of Japanese beetles if it were not for their depredations in turf and on certain trees, vines, garden plants, and crops. If they would confine their diet to smartweed, they might enjoy the aesthetic status of Egyptian scarabs or the "Gold Bug," which they resemble.

We really do not want to kill Japanese beetles; we want to prevent them from eating the plants that we value. For a few years after the beetles were discovered near Riverton, New Jersey, in 1916, entomologists tried to exterminate them by whitewashing the countryside with lead arsenate. But the beetles increased in numbers and spread until it was obvious that they could not be wiped out by insecticides. Gradually the emphasis in chemical control shifted from killing beetles to protecting plants, and in recent years entomologists have been consciously searching for repellents—substances that, when sprayed or dusted upon plants, will prevent the beetles from eating the fruit or foliage. Before the war several promising repellents were found and recommended. Last summer DDT was tested for the first time against the beetles. Fleming and Chisholm now call it "the most effective of the protective materials tested against the Japanese beetle." Its inconspicuous residue did not injure fruit or foliage of peaches, plums, or grapes, and it remained effective longer than the repellents previously recommended. It may seem ridiculous to express regret that DDT also killed many of the beetles, but if it were just a specific repellent on fruit trees and other crops that require pollination, it might not hold a threat for honeybees and other essential pollinating insects, which it is now known to kill. Consequently, DDT will have to be used with discretion for the protection of certain crops.

If anything is more important than the protection of food crops, it is the protection of troops against the attack of disease-transmitting insects, particularly malarial mosquitoes. Recent research has made oil of citronella obsolete. Now we have relatively odorless materials which, when applied to the exposed skin, will stave off mosquitoes for a few hours. Intensive research is going forward to find still better repellents and to make present repellents retain their effectiveness over a longer period of time. When our soldiers are in battle in a malarial country, only a good repellent can protect them completely against their most insidious and devastating enemies.

F.L.C.

BOOK REVIEWS

ORNAMENTAL-PLANT PESTS

Diseases and Pests of Ornamental Plants. B. O. Dodge and H. W. Rickett. Illustrated. vii + 638 pp. 1943. $6.50. The Jaques Cattell Press.

An overwhelming majority of those interested in growing ornamental plants must be amateurs. They will no doubt prefer to find their information regarding disease and animal pests of all sorts in a single volume. Dr. Westcott set the style, at least for the United States, with her *Plant Doctor* published in 1937.

The difficulty, of course, is that only rarely is any one person qualified to discuss the control of both insects and diseases. Felt and Rankin solved the problem in their *Insects and Diseases of Ornamental Trees and Shrubs* by "each being responsible for statements in his respective field."

Since both the authors of *Diseases and Pests of Ornamental Plants* are botanists, it is to be hoped that the portions dealing with insects and their control were critically read by a competent entomologist. Of this the introduction gives no evidence, and this reviewer is certainly not qualified to judge as to whether such scrutiny was needed. [It *was*, say entomologists.—Eds.]

Any book which is sincerely written must reflect the enthusiasms of the author. This is no exception. Thus we find in Part 1 "Diseases and Pests in General" of a book avowedly "intended for the person with little or no training in botany or entomology" such statements as, "In the asci of the Ascomycetes each nucleus forms a beak from which a system of rays extends; these rays mark the limits of the spore which contains the nucleus." "The asci are formed at the curved tips, known as croziers, of special hyphae in the fruiting bodies, ascocarps." "In this group the mycelium is often marked by what are called *clamp connections.* These resemble both in structure and function the croziers of the Ascomycetes"; these are matters of importance to professional mycologists, but it is hard to conceive of them as interesting to even a very enthusiastic gardener. The net result is that the chapter on insects and other animal pests is much easier reading than that on bacteria and fungi.

On the very first page it is pointed out that many common diseases result from abnormal environment or from poor cultural practices. It is more than once emphasized that new preparations or new mixtures, or control measures to which one is unaccustomed *should be tested in advance* on a few leaves or branches or on a single plant. This is sound advice too seldom given, and still more rarely followed.

The portion of the book (about 500 pages) devoted to the diseases and pests of particular hosts is of course for reference. Reading it would be tedious. For instance, spraying with Bordeaux mixture is recommended no less than two hundred times and the use of lead arsenate ninety-seven. Incidentally this gives some indication of the present importance of these old standard materials. Among the some 600 hosts included, about 75 are listed as being practically free from diseases and pests. This is useful information too often omitted from our works on plant diseases. No doubt some gardeners will be tempted to choose as many as possible of their ornamentals from this list.

A final word may be said regarding the collaboration which has produced the book. The work of each author is clearly stated in the introduction: "The factual basis of the book is contributed almost entirely by the senior author, and is based largely upon his 15 years of experience as Plant Pathologist at the New York Botanical Garden. . . . The junior author is responsible for the organization of the work and for most of the actual writing." Here is a combination of a type which could with advantage be formed more often. It requires no very wide acquaintance among working botanists to enable one to make up a list of men who through wide and varied experiences have acquired a mass of valuable information which has never been made available. Such collaboration as this might have preserved that information for the rest of us.

Neil E. Stevens

CORNELL'S PINE-LAND ENDOWMENT

The Wisconsin Pine Lands of Cornell University. Paul Wallace Gates. xi + 265 pp. 1943. $3.50. Cornell University Press.

THE story of the conversion of Wisconsin pine land into an endowment for Cornell University should interest students of American land policies, of lumber-industry history, and of the political and economic history of Wisconsin. It begins with the Morrill Act of 1862. This Act gave each public-land state 30,000 acres of land for each of its senators and representatives in Congress, and to each of the other states scrip that could be used—but not by the state itself—to acquire corresponding areas of land in the public-land states. The proceeds from sale of the land and scrip were to be used as endowments for agricultural colleges.

The states sold their scrip at what now would seem fantastically low prices. Rhode Island got only forty-two cents an acre, and most of the other states less than a dollar. Wisconsin sold her 240,000-acre grant for $1.25 an acre. New York was the only state east of the Mississippi River to obtain a reasonably adequate endowment through the Morrill Act. This was due to the vision and sustained efforts of a few men—notably Ezra Cornell, who induced the legislature to charter Cornell University and who devised and carried out the plan for using scrip to acquire timberland; Henry C. Putnam, who was largely instrumental in selecting the lands in Wisconsin; and Henry W. Sage and his associates, to whose financial support and good management was due the large profit—more than five million dollars—realized from the project.

Almost half of this book and six of its ten chapters are concerned with Federal and state land policies, the founding of Cornell University, and the rise of the lumber industry and attempts of various interests to gain control of pine timber, mainly on the Chippewa River and in adjacent territory. The rest of the book is an account of Cornell's acquisition and disposal of pine lands and of its attendant trials and tribulations.

Much space is given to the continual conflicts of Cornell's agents with politicians, railroads, and taxing authorities. The hostility of Wisconsin people to large nonresident landowners in general was intensified in the case of Cornell, because it was the largest nongovernmental pine-timber owner in the state, and because "unlike other pine-land owners, Cornell was to do little to further the growth of the state. It simply waited for the expected scarcity of timber which would assure high prices for its lands."

Cornell's investment was subject to the usual hazards of timberland speculation, such as uncertainty of future timber values, dishonesty of local land agents and timber purchasers, forest fires, loss by windstorm (one storm in 1872 blew down 200 million feet of pine in Chippewa County alone), and timber stealing, which became "a major occupation in Wisconsin." Besides, it was the policy of local residents and taxing authorities to finance improvements and government mainly by taxing lumber companies and nonresident landowners. As to whether this was attributable to selfishness, mismanagement, extravagance, and corruption, as Dr. Gates implies, opinions may differ. Cornell's tax bill on 500,000 acres of land (including between 50,000 and 100,000 acres of agricultural land), much of which was held for 15 to 25 years and some for more than 40 years, amounted to less than $650,000, or not quite one-tenth of the receipts for land and timber.

The author admits that: "A subsequent generation was to regret the destructive cutting practices of the lumbermen who destroyed irreplaceable resources in a generation, and it was to regret too the zealous work of the land companies which produced many submarginal farms and led to the settlement of areas which have since had to be abandoned. Cornell University had its share of responsibility for both misfortunes. . . . While benefiting to the amount of $5,000,000 from its investment in Wisconsin pine lands, Cornell, like other lumbermen speculators, left the pinery counties nothing to compensate them for the wealth which had been taken away."

The reader may feel disappointed that the book tells practically nothing about the exploitation of the pine timber and the subsequent use of the land. It would be interesting to know the sequel to the history of Cornell's land speculation: What is the pres-

ent condition of the lands and the forests? Who owns them? How many permanent residents and what industries do they support? What became of the lumber companies that operated on them?

It is also interesting to speculate on what might have happened if the University had held its pine a few years longer, or had established its school of forestry thirty years sooner than it did. The 400,000 to 450,000 acres of pine, managed as a sustained-yield forest, might have returned a far larger income to the University and at the same time could have been of lasting benefit to the people and State of Wisconsin.

W. N. SPARHAWK

PHYSICS TELLS WHY

Physics Tells Why. Overton Luhr. Illustrated. ix + 318 pp. 1943. $3.50. The Jaques Cattell Press.

AN alert human mind persistently asks, "the why of things." In selecting "Physics Tells Why" as the title of this book, the author has emphasized the primary characteristic of physics, the most fundamental of all the sciences. The purpose of the book, as explained by its author, is to offer trustworthy explanations and interpretations of everyday physical phenomena for those who find pleasure in understanding them. Rigorous proofs are omitted. Emphasis is placed on lucid and intimate descriptions without resource to mathematics or technical language. Physical concepts and observable phenomena are stressed. The familiar subdivisions of classical physics—mechanics, energy, heat, electricity, sound, and optics—are discussed with unusual clarity and simplicity. In making selections from the field of modern physics, preference has been given to applied electronics. There are elementary discussions of such topics as photoelectric cells and their applications to burglar alarms, talking motion pictures, and television; thermionic tubes and their uses as generators and detectors of radio waves; X-rays and their applications in medicine, dentistry, and industry. Some suggestions are made with respect to probable developments in the field of physics. They are tentative and subject to revision on the basis of new discoveries. Novel and original illustrations by Miss Ruth C. Schmidt stimulate interest and help to clarify explanations.

Those who are interested in knowing whether they have mastered the fundamental physical principles sufficiently well to apply them to specific problems will find a series of interesting questions and answers in the back of the book. An attempt to answer these questions will furnish a profitable exercise. This book should stimulate a wider interest in everyday physical phenomena; provide profitable reading for intelligent laymen; and encourage students endowed with enough curiosity about physical phenomena to make physics a scientific career. It can be very appropriately recommended as supplementary reading for college and secondary students taking a beginning course in general physics. This book, which will make the meaning and importance of physics in everyday life more widely appreciated, has been very correctly included in the Humanizing Science Series of The Jaques Cattell Press.

ALPHEUS W. SMITH

INTRODUCTION TO PSYCHIATRY

Introduction to Psychiatry. W. Earl Biddle and Mildred van Sickel. Illustrated. xiii + 358 pp. $2.75. 1943. W. B. Saunders Co.

THIS is, as the authors indicate, an "introduction to psychiatry." It is an ideal book for the student nurses just beginning to study the subject. The first half of the book deals with special psychiatric problems such as destruction, suicide, personal hygiene, patient's nutrition, etc., which the student will meet as soon as she enters the psychiatric ward. The basic terminology and symptomatology, used throughout the remainder of the book, are introduced here in simple, easily understood language. Forms of therapy significant to the care of the mentally ill are described and elaborated upon.

The nursing procedures which are illustrated, although limited in number, clearly portray the method used. The procedure for the pack is especially easy to follow. The importance of limiting hazardous articles to patients is stressed by the use of pictures showing the various weapons made by them from seemingly innocent materials.

The second half of the book deals with the

psychoses, and the manner of approach to each is interesting. The authors give a brief, concise description of the disorder, including the symptomatology; next, they present a typical case to illustrate; this they follow with a short discussion of treatment, prognosis, and prevention.

The questions at the end of each chapter cover each entity quite thoroughly and indicate to the student where the emphasis should be placed.

Although most of the definitions of technical terms are to be found in the chapter on symptomatology, it is unfortunate that there is no glossary in the book.

If the student grasps the major portion of the book she will have gained a good insight into psychiatric disorders and will have a more sympathetic appreciation of the care of the mentally ill. She likewise will have a better understanding of her own problems and of those of her associates.

DOROTHY MORRIS

EDUCATION FOR AMERICAN DEMOCRACY

Education for American Democracy. James L. Mursell. 528 pp. 1943. $3.75. W. W. Norton & Co.

IT is not surprising that there are vigorous and often conflicting arguments about education in America. That is an expected and a necessary feature of a democracy. Since the various aspects of education constitute the chief means of developing citizens, and since a democracy has committed itself to allowing a hearing for every intelligent voice, education has been and will continue to be argued about so long as the democracy tries to improve itself. Furthermore, educational philosophy, organizations, and procedure deal with such vast areas and resources, so many learners and so many teachers, that desirable changes come slowly even though leading thinkers may reach approximate agreement about possible improvements. The one thing which the majority of citizens of America will not relinquish is their belief in democratic processes, and they insist on applying these processes to their education even though the many assertive voices of advocates sometimes produce confused outcomes. If the whole mass movement is advancing, that is good. If no advancement occurs, or if there is retreat, it may be asked if democratic education is succeeding.

Professor Mursell attempts the needed task of setting down the origins and development of American public education. He shows why and how there must be some such plan as ours, lest there be no democracy. The colonial schools of Europe were tried here. Exclusive schools for those who could or would meet the obligations were tried. Training for professional life, at the outset, was in no sense a part of a general program of education. A general program of education came into existence, negatively, as a protest against undemocratic tendencies, and, positively, as a procedure which is inherent in the promises of the very essence of democracy. No one claims that we have fully discarded some of the elements of exclusive control. Conventional procedures and control of funds have been undemocratic. Indeed, it sometimes seems that control by educational "vested interests" occludes our approaching realization of the democratic education that is to be. Funds for support are essential and too often those who provide the funds control their uses. And the struggle to secure funds too often occupies the so-called thinking of would-be educational leaders. Our democratic faith must often be called into service, lest occurrences at times may unduly retard our progress. It is with most satisfying documentation that the author of this comprehensive volume regularly places before the reader the development of our present educational system. Conflicting ideas with their advocates are tied into the steadily developing story, nowhere better told.

Examples must be brief and but few of the many important topics may be used. The elective system in colleges is clearly stated within four pages including the claims of six representative persons who have given it much thought. The conclusion is that "the principle underlying the elective system is that of intellectual freedom for mature and serious persons who know what they want to do and who are therefore able to make judicious choices." A narrow, prescribed, or classical program can be maintained only by a system of prescribed examinations, and

such a system is the "practical politics of the 'great tradition'."

The Committee of Ten (1893) came at a time of greatest transition in American thinking. Its extensive and detailed reports, now often severely criticized, tried to hold the ground gained while urging education to move forward. The enforced compromises allowed subject-matter specialists to control the report. Each one prescribed for his subject a scope and content beyond possible use. They outlined curricula so extensive that no one pupil could possibly do all the requirements. But pupil elections were allowed which permitted him to miss most of the courses, and for those the courses ceased to exist. It took secondary schools a very long time to face the problems of true reorganization of subjects. Not yet is it fully recognized that most secondary pupils do not possess the qualifications stated in the principles of election as observed in the preceding paragraph. Even so, it seems likely that no national report has had more effectively helpful results than the "Report of the Committee of Ten." The author of this book presents an excellent statement of that report.

The "humanization" movement in elementary schools had its first practical chance in an educational experiment in the public schools at Quincy, Massachusetts, inaugurated by Charles Francis Adams and Colonel Francis Parker. They buttressed their experiments by definite proof that conventional procedures did not produce the results claimed for them. Added to great personal freedom for pupils there was introduced the plan of using and stimulating first-hand pupil experiences out of which to develop arithmetic, language, geography, drawing, modeling, and free talk by the pupils. Colonel Parker's goal was not only to improve scholastic efficiency but also to produce a markedly different kind of school life. This reviewer once heard Colonel Parker when he was under severe verbal attack by an educational "stand-patter." The critic closed by vehemently asking "Colonel Parker, just why did you do it?" The appropriate reply to an audience which unfortunately regarded a good laugh as good argument was, "Oh! I felt so sorry for the little duffers." Colonel Parker's long life of advocacy of freedom and of experience as basis for school work was the foundation of much recent work whose advocates sometimes seem not to know this origin. The account then follows the whole series of stages in building the present educational policy, if "a policy" is a usable expression. The author would have education face the task of constructing "a new social order," but properly believes that this must come through steady development, not cataclysm, based upon what is, and guided by the best tendencies as now discernible.

An extremely important, comprehensive, discriminating, and lengthy chapter deals with "The Human Problem of American Education." The problems of youth, ages 16 to 24, now insistent, with the return of peace "will most certainly be upon us again in aggravated form, for it is one of the perennial and inescapable problems of an industrial age." The answer to this and other human problems must be sought through "*the democratic way of life itself.*" The different solutions for different groups of problems will require more thorough and searching thought and experiment than have yet been used. These problems are then considered as they pertain to nursery, kindergarten, elementary schools, secondary schools, and higher education including adult education. Even more significant are the discussions of curricula, administration, and teacher training.

This reviewer intends to convey the impression that Professor Mursell's book is unusually factual, serious, substantial, and far-reaching. It is a treatise much needed by all who are or should be interested in education.

OTIS W. CALDWELL

DEVELOPMENT IN ADOLESCENCE

Development in Adolescence. Harold E. Jones. vii + 166 pp. 1943. D. Appleton-Century.

"JOHN has been handicapped by unhappy relationships within his family; economic stress; ill health; visual defects; an inferior physique; delayed maturity; a certain obtuseness in social contacts; lack of athletic abilities; and lack of abilities to win goals which he most desired in connection with a

strong desire for popularity and social esteem."

Through Dr. Jones' report, abstracted from voluminous data accumulated by the California Growth Study, we follow John's development from the sixth grade to his first year as a college freshman. This cautious and well-written book may be described as a broad comprehensive case study embodying the entire gamut of psychological techniques from loosely subjective comments by teachers to such "objective" methods as photo-recorded galvanic reactions to emotionally potent stimuli.

The study opens with a sociological (and somewhat social-workerish) description of John's home environment and neighborhood. A series of word pictures follows, taken through the more or less sharp lenses of teacher comments and ratings, Reputation Test ratings by classmates, direct observation reports by trained observers, ratings of social effectiveness, physiological and anthropometric measurements, psychomotor tests, interest-attitude scales, and such projective techniques as the Murray Thematic Apperception test, voice record analysis, and the ubiquitous Rorschach test. John's evaluation of himself is determined by means of self-ratings.

The composite result of these flashes reveals a personality in the process of learning to function acceptably. The difficult experience of growing into maturity is highlighted in a more persuasive fashion than is possible by means of the conventional group study.

The methodology of the California Adolescent Study deserves high commendation. Individual tests and scales are always evaluated in terms of standard scores based upon the responses of the total age group from which the individual study was taken. None of the tests are over-interpreted and facile simplification of the many-facetedness of adolescent change is avoided. The inadvisability of artificially segregating discrete traits and treating them as entities is stressed throughout the book. No single technique is given pre-eminence over the others. As the author wisely remarks, "the course of wisdom is to use more than one method in combination with other data from the life history, rather than to rely upon interpretations based on a single approach."

Parents of adolescents and all those who work with children in this age range will be encouraged by the evident tendency of the maturing personality to achieve a measure of adaptation to the social environment despite the presence of unfavorable behavioral symptoms during the formative years. As the author remarks at the conclusion of his study, "So marked an upturn in John's personal fortunes is evidence not only of the toughness of the human organism but also of the slow, complex ways in which nature and culture may come into adaptation." Teachers and counselors will also find in this book a sympathy-compelling picture of the stern requirements for successful membership in the adolescent social structure.

Dr. Jones has resisted the temptation to indulge in an elaborate theoretical interpretation of the total personality structure of his subject, thereby paying more than lip-service to the complexity of the whole personality. At times one wishes that certain parts of the book had been presented in greater detail. This is especially true of the section which deals with drives, where there is just enough to whet the appetite for more.

One is impressed by the extent to which results obtained by diverse techniques tend to corroborate each other. This should give pause to those who decry pencil-and-paper tests and questionnaires in favor of projective techniques solely. Dr. Jones is aware that there are many mansions in the house of personality and that many keys are required to unlock them.

This book is recommended for its sound approach to the problem of adolescent development. It should prove valuable as supplementary reading in courses on adolescent psychology. A good index facilitates ready reference to specific topics.

FRED BROWN

COMMENTS AND CRITICISMS

Humility

Direction of research should, to my way of thinking, be essentially informal; and I believe that the facts of its most outstanding successes will bear this out. Recently, I was especially reminded of this by the article in this journal for April, 1944—"Using Hydrogen to Save Coal"—describing the development of the hydrogen-cooled electric generator. The copy of the original memorandum sent to Chester W. Rice by Dr. Willis R. Whitney, Director of the Research Laboratory of the General Electric Co., might well be read by any executive financially responsible for an industrial research institution. With the permission of *The Scientific Monthly*, I would like to quote its first few lines:

"Dear Chester:

Could I create an interest for you in a series of fool stunts which have, I think, the promise in them of some useful outcome. . . ."

Written in longhand and undated (save for a caption signed by Rice: "Received about Feb. 21, 1921") this memorandum in its opening words exemplifies the delightfully informal spirit of true research—no hint of compulsion, of pontifical authority, of superior wisdom—just an interesting technical idea breathing true humility, from one friend to another. But what important industrial developments flowed from it! To quote again from the author of this article, Philip L. Alger: ". . . the end result of Dr. Whitney's note is that hydrogen cooling has become standard for nearly all large steam turbine driven generators in the United States."—George V. Caesar.

Heaviside

The following note may be of interest in connection with Perrine's paper in the January issue.

When the A.I.E.E. tendered a dinner to Marconi on the occasion of the first transatlantic radio message, Marconi recited a passage from one of Oliver Heaviside's papers that put him (Marconi) on the right track. As I recall the passage it ran something like the following: "Any method of transmitting messages without the use of guides must fulfill the conditions of a telegraph circuit." So simple as that!

Again when Pupin was tendered a dinner on the occasion of the first successful transcontinental telephone message, he read aloud from a paper by Oliver Heaviside that put him (Pupin) on the track of the solution of the long distance telephone problem.

I attended both dinners and made notes. Somehow or other Heaviside has never been given full credit for his remarkable work and his brilliant mathematical solutions of many electrical communication problems long before practical applications came into use.—Bassett Jones.

C. P.

Commenting on "War Effort," second item, p. 331, I regret the introduction of crudeness and vulgarity into anything that goes into so highly reputable and in all so worthily dignified a journal as *The Scientific Monthly*. I refer to "by golly" and "darn." They are plain indecencies in print and do not have to be used. The author just had to show his smartalicky way of tiding over his embarrassment, having been criticized. He was smart: he chose to draw attention to his language rather than to himself. Please keep even your letter department *clean*.—P. M. Glasoe.

Philornithy

The merit (if any) in publishing such an inept case of social reasoning(?) as the so-called "parable" of Alexander Skutch in the April *Monthly*, lies in the opportunity afforded to use the page of criticisms to refute this all too prevalent pacifism in social philosophy. (But of course these notions should be constructively refuted by offering, at much greater length, a scientific alternative in the attempt to establish peace on earth and good will among men.)

The Kingdom of Heaven may be like unto a mustard seed, but that does not make man a flycatcher. Nor is man striped until caught and punished for stealing the other fellow's possessions! The alleged analogy drawn by our naturalist friend seems a decidedly forced attempt at rationalization of a Pharisaic philosophy of pacifism, and is correspondingly mischievous, not to say iniquitous. The author may know his flycatchers, but he does not know his men or even his New Testament wherein the parables are typically drawn from human rather than from animal conduct.

Even the facts cited relative to the allegedly pacifistic species of flycatchers are ignored in the quite unwarranted analogy drawn with human affairs; for within their own species the unstriped flycatchers exhibit no such eleemosynary "philornithy" as the author, with globalonial zeal, advocates among men. On the contrary they cannot "go in search of another area" when parasitized by the striped species because "in all liklihood they would find it already in possession of another pair of their kind, who would resent (sic!) their intrusion." How un-

christian(?)—or at least, how sad for the "Utopian good-fellowship" of the author's tropical paradise!

Having been educated as a student of parasitism I have never before encountered such a quixotic notion as that which says that "the prosperity of the highly gifted"(?) host "is linked with the welfare of the deficient" parasite. The *gift* seems to me to be on the side of the parasite which has found a way of deception to enslave its victim by decoying it from its nest to where it cannot see how it has been despoiled of its eggs and is left to suppose that the nest has been pillaged by a snake or weasel and so has become untenable.

Though not too well established as yet, it is a developing virtue among men that though some may still be fooled all the time, and all may be fooled some of the time, science is supposed to come to the rescue and prevent us from fooling each other all the time. "Ye shall know the truth, and the truth shall make you free!" Eternal vigilance is the price of liberty!—Alden A. Potter.

I envy you "A Parable for Peacemakers" by Alexander F. Skutch in the April issue of *The Scientific Monthly*.—Richard W. Westwood, Editor.

Heads, Tails, and Chance

According to "the laws of chance" a coin when tossed many times will fall as often heads as it does tails, approximately. Under ideal conditions, according to these "laws," the ratio will be exactly 1 to 2. To "prove" this, mathematicians and others have sometimes devoted themselves with high scientific seriousness to the business of tossing coins for thousands and thousands of times, an example being Stanley Jevons's run of some 20,480 throws, mentioned in his *Principles of Science*. If Jevons took two seconds per throw, which would mean rather fast work, then he was at it for the equivalent of some fourteen eight-hour days; which today fills a person with wonder.

I believe there is no recorded instance of an equality of heads and tails, no matter how many throws were made. The experimental results seem to be wholly inconclusive, and we might say irrelevant, so far as "the laws of chance" are concerned, for we find it strictly maintained that "in the long run"—a run of 20,480 not being long, evidently—the anticipated equality will be realized. Professors Cohen and Nagel in their admirable *Introduction to Logic and Scientific Method* say that "from our knowledge of mechanics" we may "infer that the forces making a penny fall head are bound to balance those which make it fall tail" (p. 167). It is regrettable that they do not tell us how we know this. Mechanics or no mechanics, there is a begging of the question.

Since the equal division does not occur in experience, we may presume the meaning of "the laws of chance" to be that it will occur under ideal conditions. What are the ideal conditions contemplated? Let us say they are an ideal tosser, an ideal medium, an ideal receptacle, in addition to an ideal coin (one homogeneous and symmetrical). This will allow ideal tossing and ideal falling, which seems to mean constancy in both. But under these conditions we should indeed never see the equal division; all that we could expect would be that the side which showed after the first fall would show after every subsequent fall.

This may seem scandalous, yet the only alternative under the terms given is self-contradiction. For we should have to suppose that the effect E of conditions C was now not E; which is intolerable.

It might be objected that this presumes the tosser to hold the same side in the same position at every toss, hence that he only needs to change sides. But in that case the result would be a function of such change, and not one determined according to "laws of chance."

A further objection might be that the ideal conditions do not include but, if anything, exclude identity throughout—identity of position in each toss, of propulsion, trajectory, etc. But if they do not include these, they admit caprice, or the like; which means they are scarcely ideal.

Or one might argue that ideal conditions mean only that all bias is excluded and the phenomena are left free. But to suppose that the result will then be equality of heads and tails is nothing other than substituting naive presumption, or "equal distribution of ignorance" (Boole), for a rational solution. It is equivalent to supposing that a given event will always happen though a positive cause of it be not affirmed.

The assurance with which mathematicians and statisticians hold that heads must equal tails is hardly to be taken as so crude a presumption as this, we may suppose. It seems to have a demonstrative ground. What then might its premise be? The proposition in question, let us notice, is: A homogeneous, symmetrical coin freely tossed a large number of times under constant conditions will fall equally heads and tails. This clearly requires the premise (if it is a deduction as supposed) that all homogeneous, symmetrical bodies fall this way. Now we hardly know this latter from observation, since we do not observe, or know that we observe, all homogeneous, symmetrical bodies. So we must have it *a priori*. Not much analysis would be needed to show that it arises from logical principles, or at least that it is consistent with them; namely, the principles of contradiction and identity.

But logical principles say nothing of the physical world. They cannot tell us that nature will always

obey them, nor that nature will at random always lay out the conditions necessary to produce an equation of heads and tails. Still less can experience tell us anything so wonderful. We have no positive ground for supposing it, and the absence of such ground, or simply ignorance, is certainly no warrant for its assertion.

The supposition concealed in the paradoxical term "laws of chance," that a total absence of determination guarantees a balance of events, or some fixed ratio amongst them, is both question-begging and self-contradictory: the first self-evidently, and the second because absence of determination is certainly not determination.—Peter A. Carmichael.

Peccavimus

Unless the editors wish *The Scientific Monthly* to become a journal of controversy respecting the ethics and intelligence of scientists, it would seem that they ought to examine manuscripts submitted to them with sufficient care to prevent the publication of plain distortions of the facts. The reference is to a recent article by George A. Lundberg ("Scientists in Wartime," *The Scientific Monthly*, 58: pp. 85–95). "My point is," the author says, "that the prestige of scientists is not increased by their tendency alternately to ride the bandwagon and then, after the parade is over, to appear conspicuously in the ranks of the debunkers." He refers to "the unbelievable gullibility of many scientists," and others, although one might suppose that what is "unbelievable" need not be a matter of concern to anyone. Having little interest in the "debunkers," I need not consider that critical generalization. He mentions several people by name and happens to give a good deal of space to my article ("What Are the Fittest," *The Scientific Monthly*, 55: pp. 487–494; 56: pp. 62–70) published a little more than a year ago. From this he quotes at some length with a number of significant gaps. I should not object to his exposure of errors in my article had he found such as are undoubtedly there. It is in order, however, to protest at the gratuitous addition of errors by the use of comments that, while ostensibly descriptive or interpretive, are actually something else. One wishes to avoid the term *misrepresentation* but no other word seems applicable.

No defense is now offered for any position taken in my article, because no position taken therein has been attacked. It is only in order that errors may not go by default that attention is directed to the explicit misstatements. The intent to misrepresent is not charged or assumed. The critic in question could have been moved by some emotional reaction leading him to envision nonexistent hidden meanings. A few illustrations of what seem clearly to be irresponsible distortions will suffice.

The writer in question charges me with *scoffing* ("scoffs" is his word) at the idea that, to have world organization, we must first educate the people. It seems fair to say that this is simply untrue. The word "scoff" has a definite meaning recorded in the dictionaries. To say, as I did, that war will be educative as to the undesirability of international warfare is the reverse of derision of the significance of education. To point out that great reforms sometimes precede rather than follow general popular demand and meet with virtually universal approval is not jeering. I happen to think that the ideal in democratic administration is to anticipate *sometimes* rather than to follow *always* compelling popular demand. A professional political scientist is entitled to regard that view as unsound and based on inadequate information; to call it *scoffing* is merely to evade argument and attempt to discredit by vocabulary: is that fitting behavior for a "scientist in wartime?"

After a series of broken quotations from my article he makes the most irrelevant and misleading comment that "most social scientists would content themselves with pointing out that the implicit assumption in the above reasoning is that Germans and Japanese are carriers of war just as mosquitoes carry the germ of yellow fever." Then he blandly dismisses his assumption, obviously *not mine*, with the words: "In view of the more elementary facts of history, no informed person will want to continue the discussion beyond this point." I have too much respect for social scientists to believe that they would carry the discussion even *to* this point. Anyone who reads the original article dispassionately must see that the argument was simply this: some say wars are inevitable because we have always had them; it was once thought that plague and yellow fever were inevitable because we had always had them; it has been found possible to control yellow fever and bubonic plague; and it may well be possible to control the allegedly inevitable addiction to warfare. If one chooses to suspect that such elementary reasoning, intelligible to third grade pupils in school, must have some subtle implication, one is, of course, entitled to nurse one's own suspicious; but to strain that simple analogy so far as to relate Germans and Japanese to the "carriers of disease" is not sensible. Professor Lundberg must take the responsibility for that assumption from the words he quotes.

When he ascribes to me the doctrine of "the extermination of all who oppose the would-be exterminator's ideas as to the proper solution," he merely soars beyond the loftiest realm of fanciful imagination. It is almost absurd to reply to a misrepresentation that would be libelous if it were not so fantastic. Like almost all Americans, I dislike war; nevertheless, with all but a few thousands of our compatriots, I believe that when attacked we must fight back, and fight back with fullest possible

power. I said: "we are now confronted with war and the makers of war, and the only proper action, whether one likes it or not, is to go just as far in annihilation, or in imposition of 'durance vile,' as is necessary to create a greater impotence for warfare and a greater distaste for war than some nations have thus far had." *"Just as far . . . as is necessary"* are intelligible English words. One may not like the expressions or the basic idea, but to call this a "doctrine" of "the extermination of all who oppose the would-be exterminator's ideas as to the proper solution," is unjustifiable if not irresponsible abuse of the English language. Although regarding war as the poorest possible means of settling disputes, I, with millions of others, give approval to what the United States, Britain, Russia, and China are now doing on many fronts. If such a position is "amusing" (his word) to Professor Lundberg, the question arises as to whether his sense of humor is somewhat out of the ordinary or whether he does not understand what was written. If he disapproves what is in active progress on many fronts, his recourse is not to me but to the leaders of war activities.

Other examples of misrepresentation could be included but these are sufficient. It is possible that Professor Lundberg's apparent emotional reaction is derived from my perhaps over-bold prediction (written and spoken publicly in April, 1942, long before Casablanca and "unconditional surrender") that peace will not be based upon compact *with the vanquished;* he quotes only in part. He asks himself the rhetorical question: ". . . do I then advocate appeasement and compromise in the present war?" And he concludes that "appeasement and compromise will occur because there is, practically speaking, no alternative." No one would question his right to a belief in appeasement and compromise, whether he used these words in the sense in which they are ordinarily understood or only in a highly academic sense; nor need one doubt his right to devote several paragraphs to the attempted education of scientists and journalists as to the rules of the scientific game. We may all endorse his dictum that "the scientist, like any other citizen, should do his utmost to change the rules if he feels like it, but, while doing so, he must conform in general to the accepted rules or he will find his chance to do really effective work of any kind seriously curtailed." On the other hand, it is not out of place to suggest that Professor Lundberg himself, in writing regarding scientists, should follow the accepted rules about correct reporting.—R. E. Coker.

Touché

Dr. Byrne J. Horton's criteria for professions (*The Scientific Monthly*, February, 1944, page 164) which you state resulted from contemplation of the characteristics of the professions of law, medicine, theology and advanced teaching, certainly apply aptly to engineering (not mentioned) and to medicine, and more completely to these two than to the others named. In fact, it appears to the writer that, taking into account the terms "well-established and socially accepted scientific principles" and "scientific technique" used by Dr. Horton in Criteria 1 and 5, all would be excluded except engineering and medicine.—C. K. Harvey.

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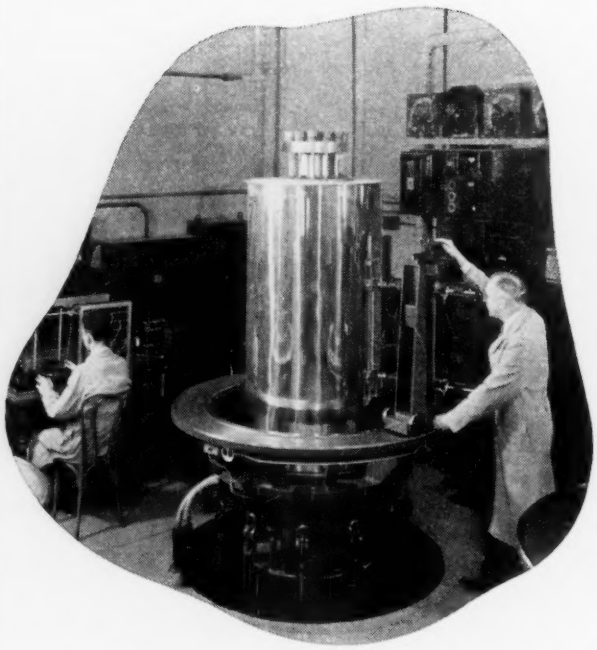

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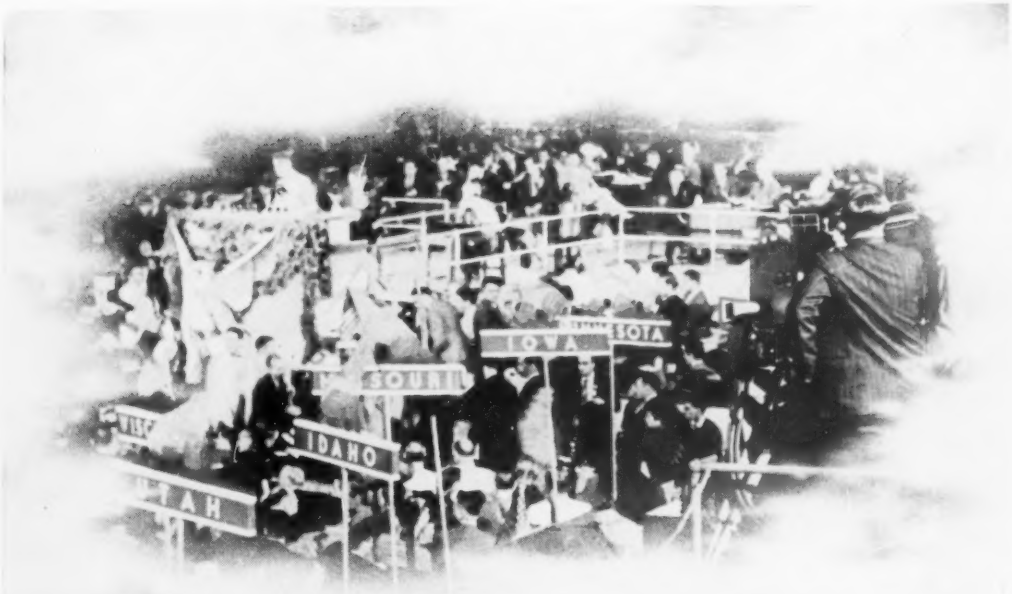

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